BENTON HARBOR POWER PLANT LIMNOLOGICAL STUDIES

PART XXVII. PHYTOPLANKTON OF THE SEASONAL SURVEYS OF 1977, AND FURTHER PRE- vs. POST-OPERATIONAL COMPARISONS AT COOK NUCLEAR PLANT

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XXVI. Entrainment of phytoplankton at the Donald C. Cook Nuclear Plant - 1976. R. Rossmann, L. D. Damaske, and N. M. Miller. 1979. 88 pp., plus Appendix of 3 microfiche cards (154 pp.).

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Ayers, J. C. 1975. The phytoplankton of the Cook Plant monthly minimal surveys during the preoperational years 1972, 1973 and 1974. Special Report No. 59 of the Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan. 51 pp.

Evans, M. S. 1978. The 1975 and 1976 operational zooplankton investigations relative to the Donald C. Cook Nuclear Power Plant with preoperational tests (1971-1976) for plant effects. Special Report No. 64 of the Great Lakes Research Division, University of Michigan, Ann Arbor, Michigan. 166 pp. Plus appendix of 4 microfiche cards.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

We are indebted to a number of persons for their contributions to the completion of this study.

Field assistance has been rendered by members of the fisheries, benthos, and zooplankton sections to whom our thanks are extended. The captain and crew of the R/V MYSIS have provided much appreciated field assistance over and above their mere duty.

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INTRODUCTION

The Donald C. Cook Nuclear Plant is located on the southeastern shore of Lake Michigan, in Lake Township, Berrien County, Michigan. The plant is approximately 11 miles south of Benton Harbor and two miles north and west of Bridgman, Michigan.

A 2-unit electric generating station, the plant is rated at 2200 megawatts and draws cooling and service water from Lake Michigan through three intake pipes from approximately 2250 feet offshore in 24 feet of water. The plant employs a once-through cooling system, returning used cooling water to the lake through two diffuser discharge structures located approximately 1200 feet offshore in 18 feet of water.

Unit 1 began operating in January 1975 and unit 2 in early 1978. With both units at full power the condenser cooling water flow rate is 1,645,000 gpm (3650 cfs) and the total heat rejection rate is 15.5 x 10^9 Btu per hour. Unit 1 at full power inparts to the condenser cooling water a temperature rise of 21.8 F^o; unit 2 at full power produces a rise of 16.7 F^o in its cooling water. Used cooling water from unit 1 returns to the lake through a 2-slot diffuser discharge structure; that from unit 2 through a 3-slot diffuser discharge structure. The exit velocities at both diffusers are about 13 ft/sec. The discharge velocities create an area of high turbulence in front of each discharge structure. The regions of high turbulence are short-lived both temporally and spatially as ambient water is rapidly entrained into the discharged water and the velocity of the discharged water falls quickly to ambient current velocity.

Phytoplankters drawn into the plant with cooling water are subject to sudden increase in temperature, mauling by pumps, chlorination of cooling water, high velocity discharge, and rapid dilution with cooler water.

Operation of the plant, then, has at least the potential of affecting the structure of the phytoplankton community.

The strategy for detecting changes in the phytoplankton community near the Cook Plant involves comparisons of phytoplankton abundances in three depth zones near the plant to abundances in the same three depth zones at distances two miles or more away from the plant. In any one survey these comparisons are spatial but, repeated over time, they allow temporal comparisons as well. The temporal comparisons primarily consist of conditions in preoperational years compared against operational years. Conditions in preoperational years provide a measure of natural variation against which variations in operational years may be compared to detect possible plant-related perturbations.

This report serves the double purpose of recording the results of seasonal surveys carried out in 1977 and of presenting additional preoperational vs postoperational analyses according to the strategy outlined above.

Figure 1 shows the station positions of the present 36-station sampling grid centered on the Cook Plant. This grid, used after April 1972, replaced an earlier 54-station grid. Table 1 compares the two sampling grids and shows the stations dropped and stations retained in changing to the 36-station grid.

At all complete stations in Figure 1 phytoplankton, zooplankton, benthos, and physical measurements are collected during the seasonal surveys. The physical measurements consist of surface-water temperature, water depth, bottom type, Secchi disc water transparency, and water color as seen above the white 20-cm Secchi disc, as well as weather conditions and wind and wave characteristics. The seasonal physical data are given in Appendix A.

Occasionally weather or logistical difficulties result in some stations of a survey being taken a day ahead of or a day later than the bulk of the stations. This results in different dates on the phytoplankton station

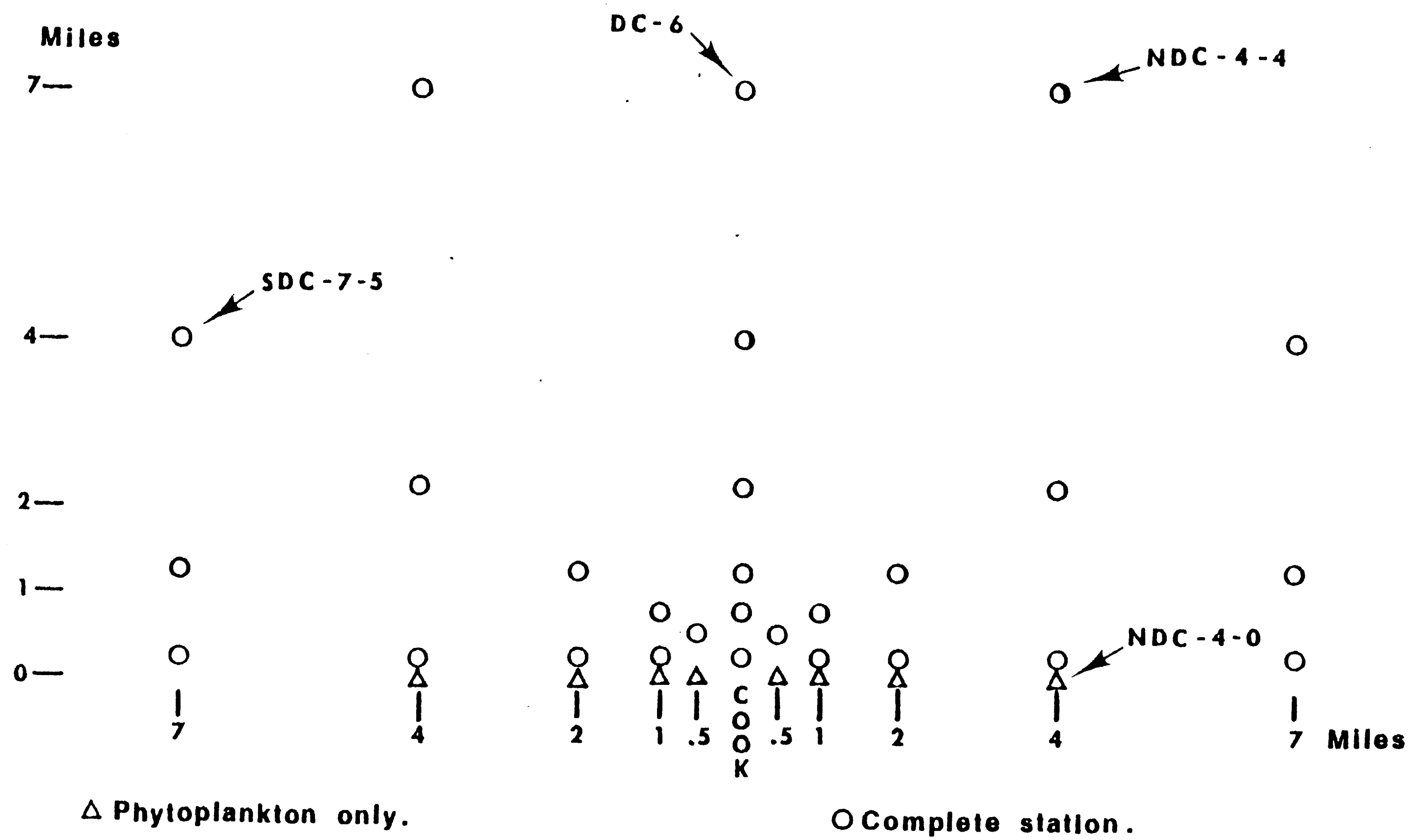

FIG. 1. The present 36-station Cook Plant sampling grid, used since April of 1972. The stations are designated as follows: SDC stations are located south of the plant, NDC stations are north of the plant, and DC stations are directly offshore of the plant. The first number in the designation is the number of miles north or south of the plant. The second number is the serial number of the station from shore lakeward. The serial number of the phytoplankton-only stations is 0.

collection sheets which are reproduced in Appendix B. It has been our custom to use the day when the bulk of the stations were taken as the date of the survey.

TABLE 1. Comparison of the original 54-station seasonal sampling grid to the 36-station sampling grid which was instituted in the July 1972 seasonal survey at Cook Plant. X denotes a retained station. -- denotes an omitted station.

Station	54-station grid	36-station grid	Station	54-station grid	36-station grid
DC-1	X	X	NDC-7-3	X	X
DC-2	X	X	NDC-7-4	X	--
DC-3	X	X	NDC-7-5	X	X
DC-4	X	X	SDC-.25-1	X	--
DC-5	X	X	SDC-.5-0	X	X
DC-6	X	X	SDC-.5-1	X	--*
NDC-.25-1	X	--	SDC-.5-2	X	X
NDC-.5-0	X	X	SDC-.5-3	X	--
NDC-.5-1	X	--*	SDC-1-0	X	X
NDC-.5-2	X	X	SDC-1-1	X	X
NDC-.5-3	X	--	SDC-1-2	X	X
NDC-1-0	X	X	SDC-1-3	X	--
NDC-1-1	X	X	SDC-2-0	X	X
NDC-1-2	X	X	SDC-2-1	X	X
NDC-1-3	X	--	SDC-2-2	X	--
NDC-2-0	X	X	SDC-2-3	X	X
NDC-2-1	X	X	SDC-2-4	X	--
NDC-2-2	X	--	SDC-4-0	X	X
NDC-2-3	X	X	SDC-4-1	X	X
NDC-2-4	X	--	SDC-4-2	X	--
NDC-4-0	X	X	SDC-4-3	X	X
NDC-4-1	X	X	SDC-4-4	X	X
NDC-4-2	X	--	SDC-7-1	X	X
NDC-4-3	X	X	SDC-7-2	X	--
NDC-4-4	X	X	SDC-7-3	X	X
NDC-7-1	X	X	SDC-7-4	X	--
NDC-7-2	X	--	SDC-7-5	X	X

* Sampled occasionally in the years since 1972.

Parts of the material presented here have been used by the Indiana & Michigan Electric Company in their Cook Plant Annual Environmental Operating Report for 1978. Other parts, including the appendices of physical data,

phytoplankton station collections, and master lists of phytoplankton collected, which were not in the company report have been added.

TECHNIQUES

Phytoplankton samples are collected by Niskin bottle from a depth of 1 m, with the exception of the nearshore stations. Nearshore collections (serial number zero stations) are made by submerging an open 1-liter bottle 4 inches below the water surface. All samples are 1-liter whole samples. Each sample is fixed with Utermohl's iodine fixative immediately after collection and stored in an opaque container.

In the laboratory, each sample is concentrated to 100 ml by settling in a 1000-ml graduate cylinder and siphoning off 900 ml of fluid. The concentrated sample is stored in a 100-ml opaque bottle.

The samples of 1971 and of April 1972 were prepared and counted by the Utermohl technique: placing an aliquot of the concentrated sample in a tubular combination settling and counting chamber and allowing the aliquot to settle overnight. The counting chamber containing the settled cells was then separated from the settling chamber, covered, and placed on the microscope. The samples were counted on a binocular inverted microscope at 1000X magnification.

Beginning with July 1972, and continuing since, the method of concentration for species identification and enumeration has been the settle-freeze method as proposed by Sanford et al. (1969). The method entails two days' settling of 1000 ml of sample in a graduated cylinder. The third day the top 900 ml are siphoned off and discarded. Part of the remaining 100 ml is used for preparation for the microscope slide and the rest is kept for any possible further references or back checking.

The once-settled sample is then diluted if need be and settled again, this time in 18-ml cylinders. These cylinders are attached with a small amount of stopcock lubricant (to prevent leakage) to the microscope slides which rest on an aluminum plate one quarter inch thick. The whole apparatus is then secured together mechanically. The microscope slides, prior to having the cylinders placed on them, were treated with Dessicote to provide a hydrophobic surface to the slide. After the samples have settled overnight, the aluminum plate on which they rest is placed on a block of dry ice for 90 seconds or less. This freezes the bottom 1-1.5 ml. The unfrozen part is then discarded and the cylinders are removed from the slides. The slides are then placed in an anhydrous ethanol chamber for 2 days, and then in a toluene chamber for 2 days.

The first chamber removes the excess water and the second prepares the samples for their final mounting in toluene based Permount®. One drop of Permount® is put on the slide, a cover slip is then placed over it, and the slide is allowed to dry for two days or more.

The specimens are counted, at 1200X under oil immersion on a Leitz Ortholux microscope, to species, variety and form when practical, otherwise to genus or group. Only those specimens that appear to have been viable at the time of collection are counted. Two sweeps of the slide are made, one vertical and one horizontal. This provides an indication of the randomness of the species on the slide.

All species are counted to individual cells, except for filamentous blue-green algae with cylindrical trichomes which are counted as individual organisms. Prior to 1974 all colonial blue-greens were counted as single organisms; the change in counting resulted in an apparent increase of blue-greens beginning in 1974.

Phytoplankton abundances derived from the counts are calculated as cells per liter, but are divided by 1000 in the computer print-outs.

Species and forms are presented in the way in which they are recognized and counted. Examples are: *Glenodinium*, a dinoflagellate, is recognized and counted separately from unidentified dinoflagellates which are given as "Dinoflagellates"; the flagellate *Cryptomonas* is recognized and counted separately from unidentified "Flagellates"; *Anacystis* and *Chroococcus* are no longer recognized as separate entities, but counted together as *Anacystis* in accordance with Drouet's (1968) revision of blue-green taxonomy.

MISSING DATA

Station SDC-4-1 was accidentally omitted in the survey of July 1977.

RESULTS AND DISCUSSIONS

The authors believe that the materials presented in this section will be more convenient for both authors and readers if presentation of the results and discussion of the results are not separated. We believe that the reader will have no difficulty in distinguishing between the objective presentation of the results and our subjective discussion of them.

The Thermal Bar of 14 April 1977

April water temperature conditions in the Cook Plant survey grid frequently range from below 4°C to above 4°C. The 4° isotherm marks the position of the line of convergence and sinking where mixing of warmer and colder waters create 4°C. The line of convergence and sinking constitutes the so-called thermal bar which is often cited as being a barrier to the mixing of inshore and offshore waters. For this reason we have made it a policy to report thermal bar conditions when they are encountered during surveys at Cook Plant.

Without entering into the controversy about whether the sinking 4° water constitutes a barrier to subsurface mixing of inshore and offshore waters, there are some points to be borne in mind about the spring thermal bar condition. The spring thermal bar develops after winter wind-mixing of the whole lake body, and waters on both sides of the bar have been nutrient-enhanced by the mixing. Formation of the sinking 4° water is by surface mixing of the inshore and offshore waters. The thermal bar moves rapidly away from shore (Rodgers 1966, page 372, found the bar in Lake Ontario moved offshore 0.5 mile in 8.5 hours) and very rapidly increases the volume of warmed water inshore of it. Since the waters on both sides of the bar contain adequate nutrients and since the sun shines on both sides of the

bar, the factor setting off phytoplankton blooms in the inshore water must be the warmth of the inshore water. In this connection it should be noted that Rodgers (op. cit., page 371) says "Whether this change [of water color across the bar] is due to impoundment of runoff, or whether the warmer water promoted the growth of biological material, is a point which requires clarification."

On 14 April 1977 the thermal bar crossed the Cook Plant survey grid just lakeward of its center. Phytoplankton densities were about 2000 cells/ml along the 4° isotherm, were somewhat higher at the lakeward edge of the grid, and were greatly higher along the shore. Figure 2 shows the position of the thermal bar in the field of contours of phytoplankton densities. Surface water temperatures ranged from less than 2° offshore to more than 10° at the beach. On this day the plant's thermal plume was small and lay around station DC-1, the first station immediately off the plant. In the plume area phytoplankton density was greater than 4000 cells/ml, although densities greater than 5000 per ml were found at station SDC-.5-2 south of the plume and at stations in the northern and southern sides of the grid.

Figure 3 presents histograms of phytoplankton densities, and of the concentrations of the conservative ions sulphate and chloride by one degree intervals of surface water temperature. Phytoplankton were most abundant in the warm water near shore. Sulphate may show some evidence of runoff being impounded by the thermal bar but a total variation of 3.4 ppm (16.8 to 20.2) is hardly an indication of significant runoff impoundment. Chloride showed no evidence of impoundment by the bar.

We conclude, as we have in the cases of other thermal bar conditions in the study area, that spring warming at the shore is the primary reason for greater phytoplankton abundance shoreward of the bar.

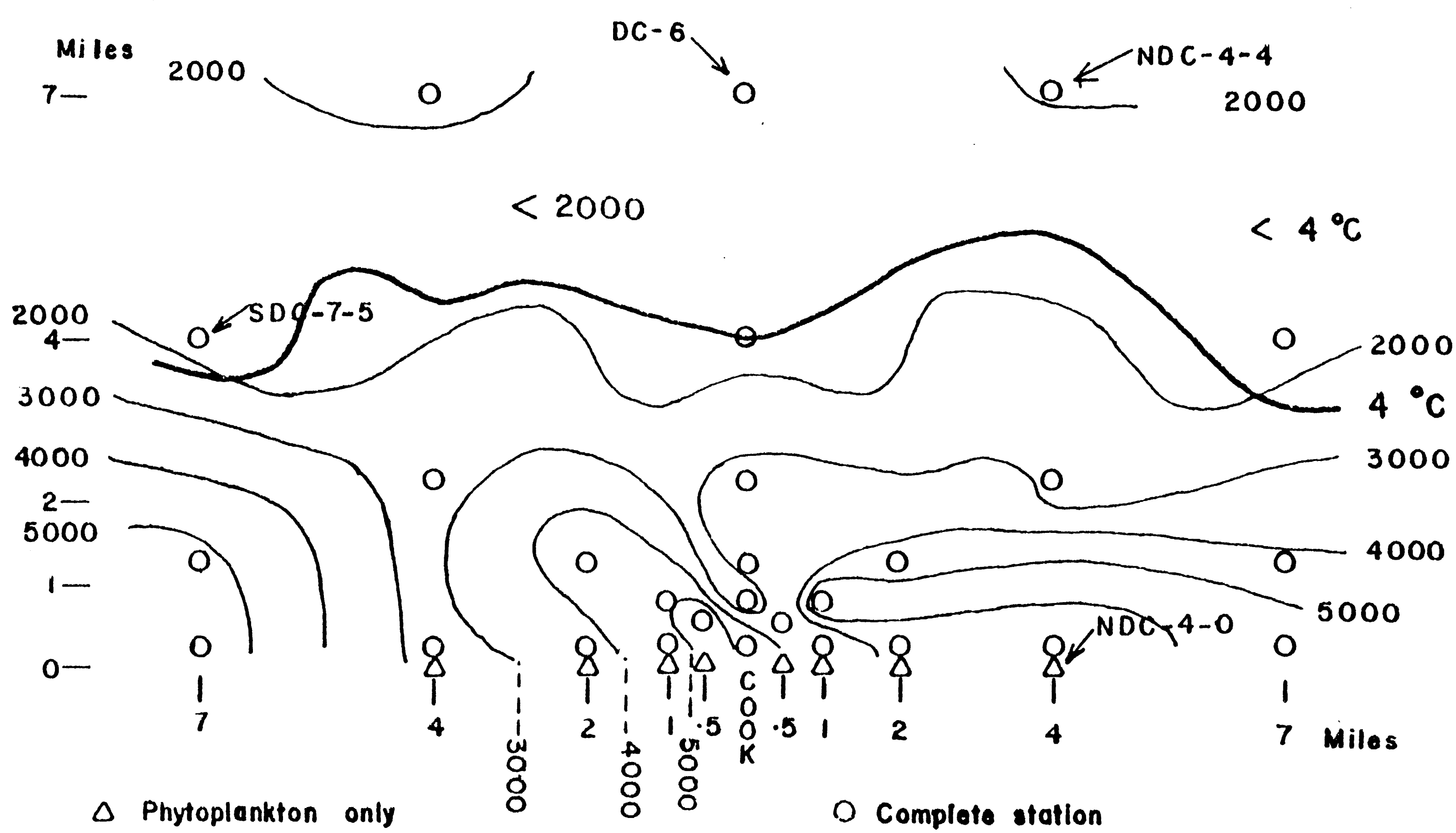

FIG. 2. The distribution of phytoplankton densities in cells per ml during the thermal bar condition of 14 April 1977. The thermal bar is indicated by the 4°C isotherm, with colder water to lakeward and warmer water landward of it.

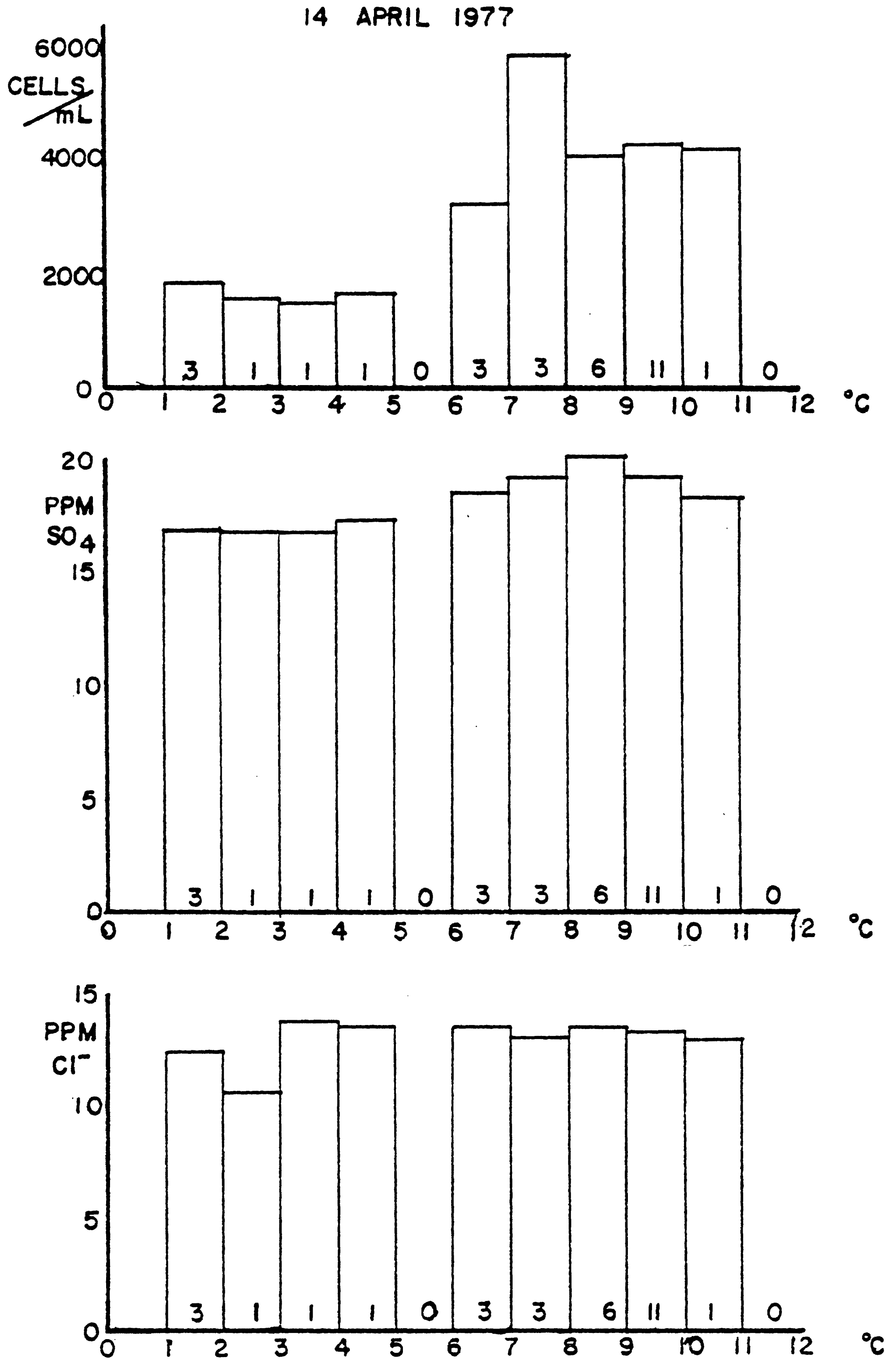

FIG. 3. Histograms of phytoplankton densities (cells/ml) and of sulphate and chloride by one C° water temperature intervals during the thermal bar condition of 14 April 1977. Numbers within the bars indicate the numbers of samples averaged.

Phytoplankton Summary Tables

The phytoplankton summary tables employed here are based on the ones used by the Michigan Water Resources Commission at the time our reporting procedures were established (MWRC, 1970). Our summaries differ from theirs in that we count the numbers of cells in filamentous and colonial forms (except blue-green algae with cylindrical trichomes which are counted as individual organisms), while the Commission counts a filament or colony as a single organism. The station collection records from which the summaries for 1977 were prepared constitute Appendix B.

The summary table for each seasonal survey presents, station-by-station, the surface-water temperature at the time of collection, the numbers per ml of each of ten major categories of planktonic algae, and the dominant (and codominant, see below) species or groups. The categories of phytoplankton employed are: coccoid blue-green algae, filamentous blue-green algae, coccoid green algae, filamentous green algae, flagellates, centric diatoms, pennate diatoms, desmids, other algae, and total algae. The summary tables allow quick assessment of the general compositions of the populations sampled, the ambient water temperature, and give the dominant and codominant species or groups (forms). The summary tables presented in Table 2 cover the surveys of spring (April), summer (July), and fall (October) of 1977.

Dominant and Codominant Phytoplankters

In each phytoplankton sample one form (species or group) is typically present in greater abundance than the others. We designate these species or groups as "dominant." In many samples, however, one or more other species or groups will come close to matching the numbers of the dominant form; we

TABLE 2. Phytoplankton summary tables. Units: cells per milliliter; surface temperature, C°. ND = Not Determined. Counts are calculated as cells per liter and divided by 1000.

Station	Tem-pera-ture	Coccoid blue-greens	Filamen-tous blue-greens	Coccoid greens	Fila-mentous greens	Flagel-lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total algae	Dominant species
						14 APRIL 1977						
DC-0	ND	0	23.2	99.5	0	1628.2	553.8	1764.2	0	56.4	4125.3	Flagellates
DC-1	10.9	0	26.5	79.6	0	2019.5	673.2	1266.8	0	155.9	4221.4	_Ochromonas_ sp.
DC-2	8.9	165.8	99.5	26.5	0	1160.6	235.4	1124.2	0	49.7	2861.8	_Fragilaria crotonensis_ _Ochromonas_ sp.
DC-3	9.0	364.8	53.1	97.8	0	1459.1	407.9	1469.0	0	51.4	3903.1	_Ochromonas_ sp. _Fragilaria crotonensis_
DC-4	6.8	0	18.2	54.7	0	1513.8	379.7	1155.7	0	51.4	3173.5	_Ochromonas_ sp.
DC-5	4.0	0	6.6	1.7	1.7	868.8	492.4	217.2	1.7	82.9	1673.0	_Ochromonas_ sp.
DC-6	1.7	0	6.6	28.2	0	618.5	583.6	104.5	0	48.1	1389.5	Flagellates
NDC-.5-0	ND	0	23.2	79.6	0	2712.6	656.6	2235.1	0	46.4	5753.5	_Synedra ostenfeldii_ Flagellates _Fragilaria crotonensis_
NDC-.5-1	9.7	0	39.8	99.5	0	2699.3	683.1	1843.8	6.6	252.0	5624.1	_Ochromonas_ sp. Flagellates
NDC-.5-2	8.8	0	34.8	74.6	5.0	1359.6	446.0	1329.8	0	89.5	3339.3	Flagellates _Fragilaria crotonensis_
NDC-1-0	ND	0	33.2	99.5	0	1923.4	517.3	1538.7	0	79.6	4191.6	Flagellates
NDC-1-1	9.0	0	46.4	66.3	0	1492.3	381.4	1051.2	0	66.3	3103.9	Flagellates _Ochromonas_ sp. _Fragilaria crotonensis_
NDC-1-2	8.8	829.0	29.8	92.9	0	2069.3	497.4	1634.9	3.3	122.7	5279.3	_Ochromonas_ sp. _Anacystis incerta_ _Fragilaria crotonensis_ Flagellates
NDC-2-0	ND	0	53.1	358.1	0	1737.7	371.4	1465.7	0	152.5	4138.5	Flagellates _Synedra ostenfeldii_ _Fragilaria crotonensis_
NDC-2-1	8.3	0	29.8	92.9	0	1953.2	388.0	1644.8	0	165.8	4274.5	Flagellates _Fragilaria crotonensis_ _Synedra ostenfeldii_
NDC-2-3	9.0	0	29.8	77.9	11.6	1444.2	719.6	1638.2	0	144.3	4065.6	Flagellates _Synedra filiformis_ _Ochromonas_ sp. _Synedra ostenfeldii_
NDC-4-0	ND	0	46.4	73.0	0	2440.7	1014.7	2301.4	0	278.6	6154.7	No dominants
NDC-4-1	7.1	0	29.8	29.8	0	2334.6	520.6	1515.5	0	76.3	4506.6	_Ochromonas_ sp.
NDC-4-3	8.2	0	46.4	39.8	0	1097.6	421.1	1004.8	3.3	245.4	2858.5	_Ochromonas_ sp.

TABLE 2. continued.

Station	Temperature	Coccoid blue-greens	Filamentous blue-greens	Coccoid greens	Filamentous greens	Flagellates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total algae	Dominant species
14 APRIL 1977 cont.												
NDC-4-4	1.8	0	3.3	38.1	0	1230.3	548.8	157.5	1.7	38.1	2017.9	Flagellates
NDC-7-1	9.0	132.6	39.8	73.0	6.6	2467.2	848.9	1843.8	0	139.3	5551.2	Flagellates
NDC-7-3	6.8	0	46.4	79.6	0	2228.4	401.3	1319.8	0	89.5	4165.1	*Ochromonas* sp.
NDC-7-5	2.8	33.2	6.6	51.4	13.3	895.4	276.9	268.6	0	34.8	1580.1	Flagellates
SDC-.5-0	ND	0	39.8	33.2	0	2958.0	460.9	1760.9	0	36.5	5289.2	Flagellates
SDC-.5-1	7.2	298.5	63.0	96.2	0	3011.0	739.5	3186.8	3.3	305.1	7703.4	*Fragilaria crotonensis* Flagellates
SDC-.5-2	9.0	0	49.7	6.6	0	2536.8	779.3	1893.5	0	76.3	5342.3	Flagellates
SDC-1-0	ND	0	53.1	338.2	6.6	3535.0	815.8	3030.9	0	159.2	7938.8	Flagellates *Ochromonas* sp. *Synedra ostenfeldii*
SDC-1-1	9.0	0	16.6	102.8	0	1329.8	746.1	2769.0	0	33.2	4997.4	*Fragilaria crotonensis*
SDC-1-2	9.2	3.3	24.9	79.6	0	1658.1	628.4	1833.8	0	46.4	4274.5	*Fragilaria crotonensis* *Ochromonas* sp.
SDC-2-0	ND	149.2	18.2	24.9	0	956.7	278.6	872.1	0	74.6	2374.3	*Ochromonas* sp.
SDC-2-1	9.1	0	19.9	119.4	9.9	1658.1	407.9	1280.0	0	139.3	3634.5	*Ochromonas* sp.
SDC-2-3	9.6	23.2	29.8	0	19.9	2662.9	378.0	1270.1	0	46.4	4430.3	Flagellates
SDC-4-0	ND	0	59.7	46.4	0	1691.2	288.5	2198.6	3.3	96.2	4383.9	*Fragilaria crotonensis*
SDC-4-1	9.0	0	3.3	59.7	0	633.4	354.8	1429.3	0	6.6	2487.1	*Fragilaria crotonensis* *Synedra filiformis* *Ochromonas* sp.
SDC-4-3	6.1	0	16.6	0	0	1422.6	252.0	792.6	0	36.5	2520.3	Flagellates
SDC-4-4	1.7	240.4	11.6	0	0	1155.7	457.6	200.6	0	71.3	2137.2	Flagellates
SDC-7-1	8.9	248.7	13.3	26.5	0	3040.9	414.5	2178.7	0	49.7	5972.3	Flagellates
SDC-7-3	7.7	348.2	19.9	46.4	0	2941.4	384.7	1628.2	0	126.0	5494.8	*Ochromonas* sp. Flagellates
SDC-7-5	3.3	0	8.3	46.4	0	654.9	412.9	349.9	0	14.9	1487.3	Flagellates *Cyclotella stelligera* *Ochromonas* sp.
						13 JULY 1977						
DC-0	ND	1077.7	6.6	514.0	13.3	732.9	1565.2	722.9	0	235.4	4868.1	*Anacystis incerta* *Fragilaria crotonensis* *Cyclotella* sp.
DC-1	22.0	16.6	587.0	179.1	0	782.6	741.2	291.8	0	79.6	2677.8	*Cyclotella michiganiana* *Anabaena flos-aquae*
DC-2	22.9	1.7	19.1	103.6	0.8	209.7	456.8	118.6	0	77.1	987.4	*Cyclotella* sp.

TABLE 2. continued.

Station	Temperature	Coccoid blue-greens	Filamentous blue-greens	Coccoid greens	Filamentous greens	Flagellates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total algae	Dominant species
13 JULY 1977 cont.												
DC-3	22.2	149.2	1178.9	306.7	1.7	577.0	744.5	341.6	1.7	81.2	3382.4	Anabaena flos-aquae
DC-4	23.0	414.5	1971.4	479.2	5.0	371.4	504.1	175.8	3.3	174.1	4098.7	Anabaena flos-aquae
DC-5	21.5	107.8	165.8	237.1	0	593.6	686.4	353.2	0	48.1	2192.0	Fragilaria crotonensis Flagellates
DC-6	ND	56.4	732.9	24.9	0	149.2	537.2	338.2	0	19.9	1858.7	Anabaena flos-aquae
NDC-.5-0	ND	968.3	28.2	122.7	5.0	421.1	1472.4	1797.3	0	69.6	4884.7	Fragilaria crotonensis
NDC-.5-1	22.8	137.6	44.8	139.3	6.6	439.4	802.5	368.1	0	64.7	2002.9	Cyclotella comensis
NDC-.5-2	23.0	6.6	585.3	215.5	11.6	484.2	645.0	320.0	0	107.8	2376.0	Anabaena flos-aquae
NDC-1-0	ND	0	13.3	205.6	0	560.4	931.8	2440.7	0	136.0	4287.8	Fragilaria crotonensis
NDC-1-1	23.2	348.2	167.5	366.4	0	587.0	1097.6	810.8	3.3	147.6	3528.4	Cyclotella comensis Fragilaria crotonensis
NDC-1-2	23.4	170.8	102.8	172.4	0	182.4	1041.3	550.5	6.6	38.1	2264.9	Cyclotella comensis Fragilaria crotonensis
NDC-2-0	ND	303.4	68.0	255.3	16.6	608.5	1114.2	979.9	0	179.1	3525.0	Fragilaria crotonensis Cyclotella comensis
NDC-2-1	22.4	0	218.9	157.5	1.7	578.7	973.3	248.7	1.7	77.9	2258.3	Cyclotella comensis
NDC-2-3	21.5	102.8	247.1	275.2	3.3	540.5	1210.4	150.9	0	92.9	2623.1	Cyclotella comensis
NDC-4-0	ND	91.2	101.1	154.2	11.6	885.4	1742.6	2376.0	0	157.5	5519.7	Fragilaria crotonensis
NDC-4-1	21.7	255.3	116.1	252.0	11.6	336.6	830.7	326.6	0	38.1	2167.1	Cyclotella michiganiana
NDC-4-3	21.2	13.3	1.7	107.8	0	427.8	1009.8	227.2	0	39.8	1827.2	Cyclotella comensis
NDC-4-4	ND	54.7	228.8	207.3	0	568.7	716.3	688.1	5.0	73.0	2541.8	Fragilaria crotonensis Cyclotella comensis
NDC-7-1	21.9	351.5	66.3	305.1	0	696.4	721.3	487.5	0	185.7	2813.7	Cyclotella michiganiana Flagellates Fragilaria crotonensis Anacystis incerta
NDC-7-3	21.0	219.7	40.6	325.8	3.3	544.7	609.3	295.1	0.8	109.4	2148.8	Cyclotella comensis
NDC-7-5	20.9	19.9	79.6	154.2	3.3	754.4	983.2	384.7	0	71.3	2450.6	Cyclotella comensis
SDC-.5-0	ND	313.4	210.6	588.6	11.6	797.5	1646.5	1490.6	1.7	283.5	5343.9	Fragilaria crotonensis
SDC-.5-1	23.0	38.1	147.6	134.3	1.7	348.2	495.8	233.8	0	121.0	1520.4	Cyclotella sp. Flagellates
SDC-.5-2	22.4	228.8	92.9	275.2	8.3	489.1	1037.9	174.1	1.7	77.9	2386.0	Cyclotella comensis
SDC-1-0	ND	0	348.2	265.3	6.6	1319.8	1760.9	1790.7	0	122.7	5614.2	Fragilaria crotonensis Cyclotella comensis
SDC-1-1	22.0	13.3	651.6	190.7	3.3	354.8	479.2	318.3	0	86.2	2097.4	Anabaena flos-aquae
SDC-1-2	22.2	6.6	111.9	15.8	0	89.5	467.6	252.0	0	29.0	972.5	Cyclotella comensis Fragilaria crotonensis

TABLE 2. continued.

Station	Temperature	Coccoid blue-greens	Filamentous blue-greens	Coccoid greens	Filamentous greens	Flagellates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total algae	Dominant species
13 JULY 1977 cont.												
SDC-2-0	ND	510.7	3.3	185.7	23.2	467.6	1485.6	974.9	0	116.1	3767.1	Cyclotella comensis Fragilaria crotonensis
SDC-2-1	23.0	523.9	36.5	68.0	1.7	222.2	679.8	41.5	0	96.2	1669.7	Anacystis incerta Cyclotella sp.
SDC-2-3	23.0	0	1916.7	200.6	5.0	782.6	973.3	189.0	0	195.7	4262.9	Anabaena flos-aquae
SDC-4-0	ND	573.7	1372.9	490.8	13.3	1034.6	1419.3	1014.7	3.3	328.3	6250.9	Anabaena flos-aquae
SDC-4-3	22.0	61.3	71.3	247.1	5.0	761.1	711.3	165.8	0	112.7	2135.6	Flagellates
SDC-4-4	22.2	0	235.4	162.5	0	648.3	587.0	220.5	0	29.8	1883.6	Flagellates Cyclotella comensis Anabaena flos-aquae
SDC-7-1	23.0	86.2	102.8	18.2	0	128.5	405.4	3.3	0	12.4	756.9	Cyclotella sp.
SDC-7-3	22.3	100.3	832.3	46.4	0	287.7	639.2	266.9	0.8	51.4	2225.1	Anabaena flos-aquae
SDC-7-5	21.9	249.5	237.9	109.4	0	404.6	428.6	204.8	1.7	29.8	1666.4	Flagellates Anabaena flos-aquae Fragilaria crotonensis
14 OCTOBER 1977												
DC-0	ND	199.0	13.3	480.8	3.3	102.8	716.3	1154.0	0	199.0	2868.4	Fragilaria crotonensis
DC-1	15.0	2192.0	16.6	86.2	6.6	941.8	271.9	557.1	3.3	169.1	4244.6	Anacystis incerta
DC-2	12.2	179.1	5.0	97.8	0	565.4	252.0	359.8	3.3	68.0	1530.4	Flagellates
DC-3	12.0	3677.6	6.6	137.6	0	732.9	217.2	429.4	1.7	134.3	5337.3	Anacystis incerta
DC-4	12.1	1260.1	3.3	59.7	0	669.9	172.4	175.8	0	140.9	2482.1	Gomphosphaeria lacustris Anacystis incerta
DC-5	12.2	1812.3	1.7	38.1	5.8	438.6	136.8	39.8	0.8	50.6	2524.4	Anacystis incerta Gomphosphaeria lacustris
DC-6	12.4	3077.4	1.7	104.5	0	595.2	129.3	200.6	1.7	18.2	4128.6	Anacystis incerta
NDC-.5-0	ND	1475.7	49.7	268.6	19.9	242.1	683.1	1074.4	3.3	165.8	3982.7	Anacystis incerta Gomphosphaeria lacustris
NDC-.5-1	12.1	5418.6	6.6	218.9	0	1270.1	202.3	1406.0	0	96.2	8618.6	Anacystis incerta
NDC-.5-2	13.5	1414.3	3.3	66.3	0	354.8	144.3	915.3	1.7	169.1	3069.1	Gomphosphaeria lacustris
NDC-1-0	ND	1780.8	106.1	305.1	53.1	384.7	988.2	1555.3	0	348.2	5521.3	Anacystis incerta
NDC-1-1	12.0	475.9	0	117.7	0	887.1	213.9	684.8	1.7	117.7	2498.7	Flagellates
NDC-1-2	13.0	2434.0	16.6	71.3	0	615.1	164.1	620.1	3.3	97.8	4022.5	Anacystis incerta
NDC-2-0	ND	179.1	102.8	417.8	0	351.5	1910.1	1256.8	0	487.5	4705.6	Melosira granulata
NDC-2-1	11.9	926.9	8.3	76.3	0	1331.4	260.3	834.0	0	97.8	3535.0	Flagellates
NDC-2-3	11.9	1681.3	38.1	286.8	0	780.9	318.3	726.2	0	144.3	3976.0	Anacystis incerta

TABLE 2. continued.

Station	Temperature	Coccoid blue-greens	Filamentous blue-greens	Coccoid greens	Filamentous greens	Flagellates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total algae	Dominant species
14 OCTOBER 1977 cont.												
NDC-4-0	ND	53.1	185.7	378.0	6.6	497.4	4112.0	2526.9	6.6	192.3	7958.7	Melosira granulata
NDC-4-1	11.9	931.8	3.3	252.0	0	1323.1	275.2	1930.0	3.3	73.0	4791.8	Fragilaria crotonensis Flagellates Anacystis incerta
NDC-4-3	11.9	2735.8	9.9	162.5	0	832.3	358.1	401.3	0	59.7	4559.7	Anacystis incerta
NDC-4-4	12.4	736.2	43.1	56.4	0	552.1	140.9	33.2	0	48.1	1610.0	Anacystis incerta
NDC-7-1	12.2	925.2	202.3	102.8	0	1011.4	394.6	650.0	3.3	66.3	3355.9	Flagellates Gomphosphaeria lacustris
NDC-7-3	12.0	1183.9	13.3	137.6	0	829.0	379.7	688.1	3.3	109.4	3344.3	Anacystis incerta Gomphosphaeria lacustris Flagellates
NDC-7-5	12.0	2951.4	0	76.3	0	492.4	139.3	257.0	1.7	34.8	3952.8	Anacystis incerta
SDC-.5-0	ND	553.8	23.2	215.5	16.6	238.8	431.1	935.1	3.3	212.2	2629.7	Fragilaria crotonensis Anacystis incerta
SDC-.5-1	12.5	8157.7	73.0	252.0	0	2235.1	364.8	1903.5	0	106.1	13092.1	Gomphosphaeria lacustris
SDC-.5-2	12.2	2215.2	9.9	358.1	0	1402.7	490.8	908.6	0	182.4	5567.8	Anacystis incerta
SDC-1-0	ND	56.4	9.9	208.9	0	238.8	447.7	653.3	0	205.6	1820.6	Fragilaria crotonensis Flagellates
SDC-1-1	12.5	1585.1	33.2	447.7	3.3	1379.5	361.5	1190.5	0	53.1	5053.8	Anacystis incerta Flagellates
SDC-1-2	12.6	1512.2	13.3	43.1	0	716.3	291.8	328.3	0	116.1	3021.0	Gomphosphaeria lacustris
SDC-2-0	ND	1780.8	3.3	275.2	0	235.4	789.2	2268.2	0	36.5	5388.7	Fragilaria crotonensis Anacystis incerta
SDC-2-1	12.8	580.3	0	106.1	0	570.4	331.6	470.9	0	86.2	2145.5	Flagellates Anacystis incerta
SDC-2-3	12.2	2022.8	6.6	159.2	6.6	726.2	228.8	275.2	0	82.9	3508.5	Agmenellum quadruplicatum
SDC-4-0	ND	278.6	0	172.4	0	252.0	444.4	2420.8	0	6.6	3574.8	Fragilaria crotonensis
SDC-4-1	11.9	4960.9	13.3	411.2	0	1591.7	596.9	782.6	6.6	271.9	8635.2	Anacystis incerta
SDC-4-3	12.2	4659.2	19.9	36.5	0	842.3	112.7	238.8	5.0	28.2	5942.5	Gomphosphaeria lacustris
SDC-4-4	12.8	1324.8	0	104.5	0	873.8	81.2	23.2	0	68.0	2475.5	Gomphosphaeria lacustris
SDC-7-1	12.2	427.8	9.9	46.4	0	540.5	212.2	397.9	0	69.6	1704.5	Flagellates Anacystis incerta
SDC-7-3	12.5	4294.4	34.8	107.8	0	756.1	252.0	432.8	5.0	208.9	6091.7	Anacystis incerta Gomphosphaeria lacustris
SDC-7-5	12.3	873.8	23.2	11.6	0	359.8	89.5	102.8	0	58.0	1518.8	Anacystis incerta Gomphosphaeria lacustris

designate these slightly less abundant forms "codominants" and list them along with the dominant in the "Dominant species" column of Table 2.

TABLE 3. The dominant and codominant phytoplankters in the Cook Plant seasonal surveys of preoperational 1970 through 1974 and operational 1975 through 1977.

Survey	Species or group	Dominant or codominant occurrences
10 JULY 1970	*Tabellaria fenestrata* (diatom)	40
	Cyclotella sp. (diatom)	9
	Fragilaria crotonensis (diatom)	7
	Melosira sp. (diatom)	3
	Dinobryon divergens (flagellate)	2
	Flagellates	2
	Melosira granulata (diatom)	2
	Melosira granulata v. *angustissima* (diatom)	2
	Oocystis solitaria (green alga)	2
	Anabaena circinalis (blue-green alga)	1
	Chlamydomonas sp. (flagellate)	1
	Microcystis aeruginosa (blue-green alga)	1
	Melosira islandica (diatom)	1
	Melosira italica (diatom)	1
25 SEPT 1970	*Chlamydomonas* sp. (flagellate)	28
	Fragilaria crotonensis (diatom)	13
	Dinobryon divergens (flagellate)	10
	Oocystis sp. (green alga)	10
	Gloeocystis sp. (green alga)	7
	Melosira granulata (diatom)	7
	Chroococcus limneticus (blue-green alga)	4
	Ochromonas sp. (flagellate)	3
	Melosira granulata v. *angustissima* (diatom)	2
	Peridinium sp. (flagellate)	2
	Closteriopsis sp. ("other" alga*)	1
	Cryptomonas sp. (flagellate)	1
	Cyclotella sp. (diatom)	1
	Tabellaria fenestrata (diatom)	1
	Tetraedron minimum ("other" alga*)	1
12 NOV 1970	*Ochromonas* sp. (flagellate)	33
	Chlamydomonas sp. (flagellate)	19
	Cryptomonas sp. (flagellate)	3
	Fragilaria crotonensis (diatom)	3
	Crucigenia rectangularis ("other" alga*)	1
	Cyclotella sp. (diatom)	1

TABLE 3. continued

Survey	Species or group	Dominant or codominant occurrences
15 APRIL 1971	*Ochromonas* sp. (flagellate)	24
	Melosira sp. (diatom)	15
	Chlamydomonas sp. (flagellate)	15
	Tabellaria fenestrata (diatom)	14
	Stephanodiscus sp. (diatom)	13
	Fragilaria crotonensis (diatom)	9
	Cyclotella sp. (diatom)	6
	Fragilaria sp. (diatom)	1
9 JULY 1971	*Gloeocystis* sp. (green alga)	47
	Oocystis sp. (green alga)	18
	Glenodinium sp. (flagellate)	12
	Dinobryon divergens (flagellate)	10
	Tabellaria fenestrata (diatom)	8
	Cyclotella sp. (diatom)	4
	Fragilaria crotonensis (diatom)	3
	Scenedesmus sp. ("other" alga*)	1
	Crucigenia sp. ("other" alga*)	1
	Fragilaria sp. (diatom)	1
	Westella linearis (green alga)	1
8 NOV 1971	*Ochromonas* sp. (flagellate)	20
	Tabellaria fenestrata (diatom)	17
	Fragilaria crotonensis (diatom)	7
	Gloeocystis sp. (green alga)	6
	Chlamydomonas sp. (flagellate)	4
	Cryptomonas sp. (flagellate)	3
	Aphanothece sp. (blue-green alga)	2
	Oocystis sp. (green alga)	1
	Fragilaria sp. (diatom)	1
12 APRIL 1972	*Tabellaria fenestrata* (diatom)	13
	Chlamydomonas sp. (flagellate)	8
	Cyclotella sp. (diatom)	7
	Stephanodiscus sp. (diatom)	6
	Gloeocystis sp. (green alga)	4

TABLE 3. continued

Survey	Species or group	Dominant or codominant occurrences
16 JULY 1972	*Tabellaria fenestrata* (diatom)	14
	Gloeocystis sp. (green alga)	5
	Chlamydomonas sp. (flagellate)	5
	Fragilaria intermedia (diatom)	4
	Fragilaria capucina (diatom)	4
	Fragilaria crotonensis (diatom)	3
	Dinobryon sp. (flagellate)	3
	Flagellates	2
	Anabaena sp. (blue-green alga)	2
	Glenodinium sp. (flagellate)	1
	Oocystis sp. (green alga)	1
15 OCT 1972	*Melosira granulata* (diatom)	26
	Chroococcus limneticus (blue-green alga)	4
	Flagellates	3
	Chroococcus sp. (blue-green alga)	2
25 APRIL 1973	*Stephanodiscus minutus* (diatom)	21
	Flagellates	12
	Cyclotella sp. (diatom)	5
	Stephanodiscus sp. (diatom)	3
	Fragilaria crotonensis (diatom)	1
	Gloeocystis sp. (green alga)	1
	Chlamydomonas sp. (flagellate)	1
	Melosira granulata (diatom)	1
	Tabellaria fenestrata v. *intermedia* (diatom)	1
19 JULY 1973	*Stephanodiscus tenuis* (diatom)	19
	Cyclotella stelligera (diatom)	10
	Melosira granulata v. *angustissima* (diatom)	4
	Chlamydomonas sp. (flagellate)	4
	Cyclotella sp. (diatom)	2
	Cyclotella atomus (diatom)	1
	Anacystis incerta (blue-green alga)	1
	Flagellates	1
	Gloeocystis sp. (green alga)	1
	Coccomyxa coccoides (green alga)	1
23 OCT 1973	*Melosira granulata* v. *angustissima* (diatom)	20
	Flagellates	9
	Chlamydomonas sp. (flagellate)	3
	Fragilaria crotonensis (diatom)	2
	Melosira granulata (diatom)	1

TABLE 3. continued

Survey	Species or group	Dominant or codominant occurrences
20 APRIL 1974	*Fragilaria crotonensis* (diatom)	20
	Flagellates	18
	Stephanodiscus tenuis (diatom)	11
	Synedra filiformis (diatom)	3
	Fragilaria intermedia v. *fallax* (diatom)	1
	Melosira granulata (diatom)	1
	Melosira italica (diatom)	1
	Stephanodiscus minutus (diatom)	1
11 JULY 1974	*Fragilaria crotonensis* (diatom)	27
	Flagellates	21
	Anacystis incerta (blue-green alga)	2
	Anabaena flos-aquae (blue-green alga)	1
	Cyclotella stelligera (diatom)	1
	Tabellaria fenestrata v. *intermedia* (diatom)	1
	Thalassiosira pseudonana (diatom)	1
	Stephanodiscus tenuis (diatom)	1
9 OCT 1974	*Anacystis incerta* (blue-green alga)	22
	Flagellates	21
	Gomphosphaeria lacustris (blue-green alga)	11
	Anacystis thermalis (blue-green alga)	3
	Fragilaria crotonensis (diatom)	2
	Asterionella formosa (diatom)	1
	Melosira granulata (diatom)	1
	Stephanodiscus minutus (diatom)	1
	Stephanodiscus tenuis (diatom)	1
17 APRIL 1975	Flagellates	24
	Stephanodiscus tenuis (diatom)	17
	Fragilaria crotonensis (diatom)	15
	Stephanodiscus minutus (diatom)	8
	Cyclotella stelligera (diatom)	7
	Tabellaria flocculosa (diatom)	3
	Tabellaria fenestrata v. *intermedia* (diatom)	1
	Melosira islandica (diatom)	1
	Anacystis incerta (blue-green alga)	1
	Fragilaria capucina (diatom)	1
	Fragilaria intermedia (diatom)	1
	Synedra filiformis (diatom)	1

TABLE 3. continued

Survey	Species or group	Dominant or codominant occurrences
17 JULY 1975	*Gloeocystis* sp. (green alga)	20
	Flagellates	15
	Anabaena flos-aquae (blue-green alga)	10
	Green coccoid unknown	4
	Fragilaria crotonensis (diatom)	1
	Cyclotella stelligera (diatom)	1
	Gloeocystis planctonica (green alga)	1
17 OCT 1975	*Anacystis incerta* (blue-green alga)	22
	Gomphosphaeria lacustris (blue-green alga)	15
	Fragilaria crotonensis (diatom)	9
	Flagellates	5
	Anabaena flos-aquae (blue-green alga)	1
	Gloeocystis sp. (green alga)	1
	Ochromonas sp. (flagellate)	1
	Synedra filiformis (diatom)	1
14 APRIL 1976	Flagellates	23
	Fragilaria crotonensis (diatom)	18
	Asterionella formosa (diatom)	16
	Stephanodiscus sp. (diatom)	8
	Anacystis incerta (blue-green alga)	4
	Stephanodiscus subtilis (diatom)	4
	Rhizosolenia gracilis (diatom)	2
	Stephanodiscus minutus (diatom)	2
	Gomphosphaeria lacustris (blue-green)	1
	Ulothrix sp. (green alga)	1
14 JULY 1976	Flagellates	24
	Gloeocystis sp. (green alga)	12
	Anabaena flos-aquae (blue-green)	9
	Gomphosphaeria lacustris (blue-green)	4
	Anacystis incerta (blue-green)	2
	Cyclotella stelligera (diatom)	2
	Fragilaria crotonensis (diatom)	2
	Gloeocystis planctonica (green alga)	1
	Oocystis sp. (green alga)	1
	Pediastrum duplex ("other" alga*)	1

TABLE 3. continued

Survey	Species or group	Dominant or codominant occurrences
14 OCT 1976	Flagellates	28
	Fragilaria crotonensis (diatom)	11
	Gomphosphaeria lacustris (blue-green)	8
	Anacystis incerta (blue-green)	6
	Cyclotella comensis (diatom)	5
	Gloeocystis sp. (green alga)	5
	Anabaena flos-aquae (blue-green)	1
	Gloeocystis planctonica (green alga)	1
	Melosira granulata (diatom)	1
14 APRIL 1977	Flagellates	24
	Ochromonas sp. (flagellate)	19
	Fragilaria crotonensis (diatom)	13
	Synedra ostenfeldii (diatom)	5
	Synedra filiformis (diatom)	2
	Anacystis incerta (blue-green alga)	1
	Cyclotella stelligera (diatom)	1
13 JULY 1977	*Fragilaria crotonensis* (diatom)	15
	Cyclotella comensis (diatom)	15
	Anabaena flos-aquae (blue-green alga)	11
	Flagellates	6
	Cyclotella sp. (diatom)	5
	Anacystis incerta (blue-green alga)	3
	Cyclotella michiganiana (diatom)	3
14 OCT 1977	*Anacystis incerta* (blue-green alga)	24
	Gomphosphaeria lacustris (blue-green alga)	12
	Flagellates	10
	Fragilaria crotonensis (diatom)	6
	Melosira granulata (diatom)	2
	Agmenellum quadruplicatum (blue-green alga)	1

* A green alga, but coded as "other" because it is neither filamentous nor coccoid.

In Table 3 the dominant and codominant forms in the stations of each seasonal survey of 1970 through 1977 have been assembled and the numbers of their dominant or codominant occurrences given. This is done to assist the

reader in sorting the probably important dominants and codominants from the rare ones which might be due to the chance capture of a single many-celled filament or colony.

When the cases of multiple (more than one) dominance or codominance are summarized by algal type, the following is obtained:

	Blue-greens	Greens	Flagellates	Diatoms
1970				
July		1	2	6
Sep.	1	2	4	3
Nov.	—	—	3	1
	1	3	9	10
1971				
Apr.			2	5
July		2	2	3
Nov.	1	1	3	2
	1	3	7	10
1972				
Apr.		1	1	3
July	1	1	3	4
Oct.	2	—	1	1
	3	2	5	8
1973				
Apr.			1	3
July			1	4
Oct.			2	2
			4	9
1974				
Apr.			1	3
July	1		1	1
Oct.	3		1	1
	4		3	5
1975				
Apr.			1	5
July	1	2	1	
Oct.	2	—	1	1
	3	2	3	6
1976				
Apr.	1		1	6
July	3	1	1	2
Oct.	2	1	1	2
	6	2	3	10

1977			
Apr.		2	3
July	2	1	4
Oct.	2	1	2
	4	4	9

Except for the greater number of dominant and codominant blue-greens in 1976, the numbers and types of dominants and codominants during the operational years are within the range of normal variation established in the preoperational years. It is unlikely that the increased blue-greens in 1976 were an effect of plant operation, for they returned to the normal range of numbers in 1977 when the plant operated at full power for much more of the year than it had in 1976.

Beginning in 1972 there has been a trend toward increasing numbers of blue-green algae as dominants and codominants. This conforms with the findings by Tarapchak and Stoermer (1976) and others that in recent years blue-greens have increased in Lake Michigan as a result of summer depletion of silica in the epilimnion. Heavy dominance by the blue-greens *Anacystis incerta* and *Gomphosphaeria lacustris* first appeared in October 1974 and has been characteristic of Octobers in subsequent years. It is attributable to summer silica depletion, not to any effect of plant operation.

Master Lists of Phytoplankters Collected

Appendix C presents the lists of phytoplankters collected in the seasonal surveys of 1977. Ayers (1978) lists the collections of 1976 and previously unreported September 1970. Ayers, Southwick, and Robinson (1977) give the master lists for the surveys of 1974 and 1975. Ayers (1975) presents the lists for the surveys of 1972 and 1973. Ayers, Mozley, and Stewart (1974) list the species collected in the seasonal surveys of 1971. Ayers, Mozley, and Roth (1973) give the master list for November 1970. Ayers

et al. (1971) list the species taken in the July survey of 1970.

Over time, the master lists provide a means of watching for changes in the phytoplankton community. The master lists of 1972 (when the settle-freeze method was adopted) through 1977 have been put to this use in the section that follows.

Continued Increase of a New Diatom Species

The centric diatom, *Cyclotella comensis*, first appeared in Cook Plant phytoplankton collections in October 1975 and has been taken with increasing regularity in the seasonal surveys since then. The record on occurrences of *C. comensis* now stands:

	1975		1976			1977		
	Jul.	Oct.	Apr.	Jul.	Oct.	Apr.	Jul.	Oct.
Number of occurrences	0	24	13	6	35*	29	38**	39
Percent of samples containing it	0	66	33	15	100	74	100	100
Range of % of sample populations	0	0-1.77	0-0.59	0-0.24	0.60-25.80	0-0.65	1.25-36.75	0.27-3.35
Mean % of sample populations	0	0.58	0.06	0.02	6.52	0.16	15.20	1.29
Number of dominant or codominant occurrences	0	0	0	0	5	0	15	0

* Four stations omitted due to high seas.
** Station SDC-4-1 was accidentally omitted in this survey.

Cyclotella comensis is known from alpine lakes, Lake Superior, Lake Huron and Saginaw Bay, as well as northern and central Lake Michigan. Aside from the fact that it blooms in late summer or early fall, nothing is known of the requirements or preferenda of this diatom. Previous collections of

this entity from other parts of the Great Lakes argue that its appearance and increase in the Cook Plant collections are due to some change in the lake, not to the operation of the plant.

Its failure to bloom in October 1977 is completely consistent with a late summer depletion of silica in the epilimnion.

Major Algal Group Percentages at Plant and Reference Stations, 1970-1977

Figure 4 presents the year to year variations in the proportions of five major algal categories at four stations in front of the plant and at two reference stations located seven miles north and south of the plant. The intent is to obtain from the preoperational years indications of the similarity in population composition at the two sets of stations and to look in the operational years for dissimilarities that might be the results of plant operation.

The plant stations (stations DC-0, DC-1, NDC-.5-1, and SDC-.5-1) are shallow water stations near the plant's discharges where discharged waste heat could be expected to be present most often. The reference stations, NDC-7-1 and SDC-7-1, are also shallow water stations but each is seven miles from the plant where waste heat should not be expected.

In the computations for the figure, the densities in cells/ml of each of the ten categories of algae in the summary tables have been averaged and the mean abundance of each expressed as a percent of mean total algae. Coccoid and filamentous blue-greens have been combined, as have coccoid and filamentous greens, centric and pennate diatoms, and desmids and other algae. The percentages have been progressively summed in plotting the graphs. A change in method of counting blue-greens, introduced in 1974, resulted in an abrupt increase in that year and it has continued since.

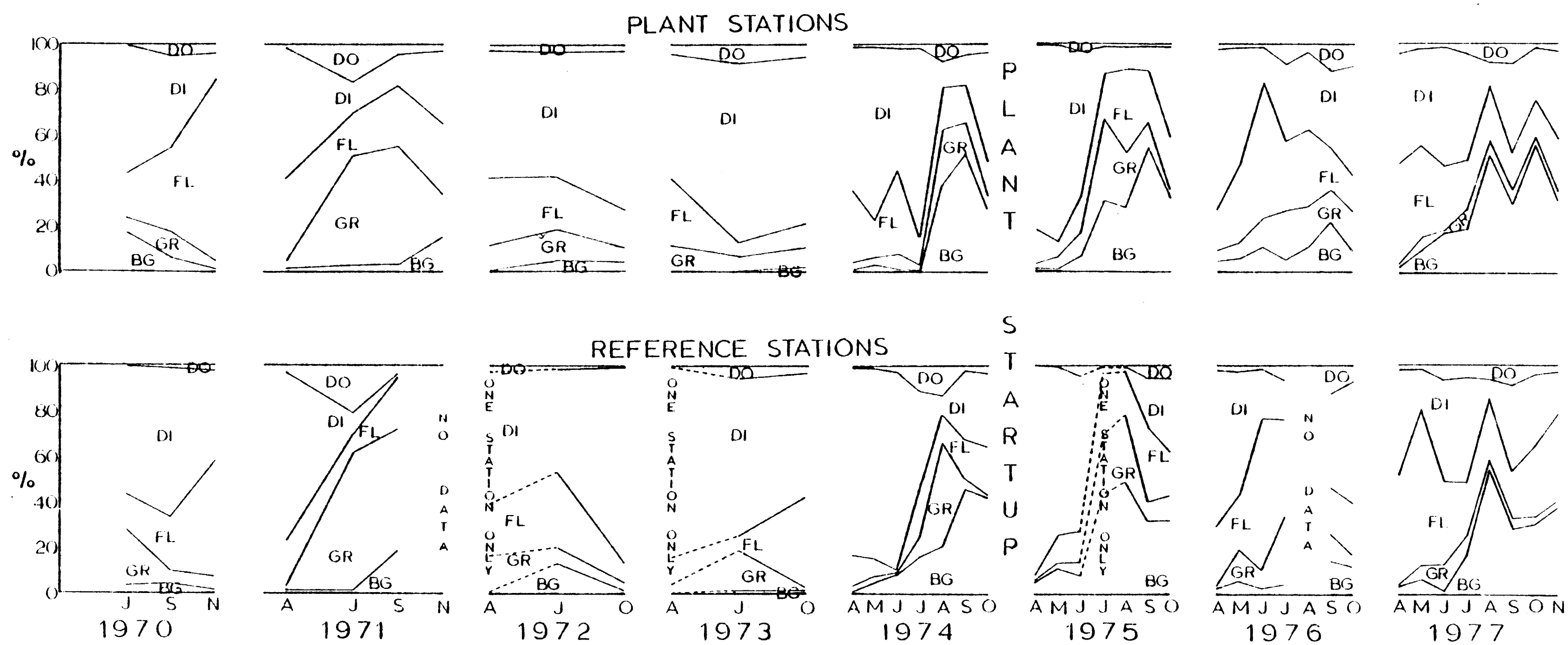

FIG 4. Major group compositions of the Cook Plant region phytoplankton from July 1970 through November 1977. The upper graphs are based on mean abundances at four stations near the plant: NDC-.5-1, SDC-.5-1, DC-0, and DC-1. The lower graphs are based on mean abundances at the reference stations NDC-7-1 and SDC-7-1, each seven miles from the plant. Blue-greens are abbreviated as BG, greens as GR, flagellates as FL, diatoms as DI, and desmids and other algae as DO.

Ayers (1978) explains the missing data and discusses the degrees of similarity in population compositions at the two station groups. On the whole, the temporal changes of the component parts of the phytoplankton communities at the two station groups have been qualitatively similar in the preoperational years; only in the flagellates and green algae in 1973 were the changes directionally different in the two station sets. In the operational years the compositional changes in the communities at the plant and reference stations have been, if anything, even more similar than in the preoperational period.

In both the plant and the reference stations in 1975 flagellates represented a greater proportion of the population than in 1974, though not so great a one as was observed in September-November 1970 and about the same as in July 1972. As a result of the warmer summer, flagellates in both station groups reached their greater abundances a month earlier than in 1974.

Green algae in both plant and reference stations began their greater abundances in July 1975, again an effect of the warmer summer. In neither station group did these algae reach the massive proportions of the populations that were observed in 1971.

In 1976 the partitionings of the five components of the phytoplankton populations were, in both the plant stations and the reference stations, different from those observed in previous years. Blue-green and green algae did not exhibit the pronounced maxima or minima of other years. Flagellates in both station groups were generally a higher and more sustained proportion of the population than in other years. Desmids and other algae peaked in September, which had not been seen before. The summer diatom minimum occurred in June in the plant stations and in June and July in the reference stations; in both sets of stations the minima were less severe than in 1974

or 1975. In general, it appears that in 1976 flagellates and desmids and other algae increased at the expense of diatoms, coccoid and filamentous greens, and blue-green algae in both the plant and the reference stations.

In 1977 blue-greens returned to the summer peak levels of 1974 and 1975. Green algae, in both sets of stations, were a minor part of the population in each of the surveys. Flagellates were somewhat more abundant in spring 1977 than in the springs of preceeding years and had a May peak in abundance at the expense of the diatoms. Diatom summer minima occurred in August in each station set; a second minimum occurred in October at the plant stations and in November in the reference stations. Desmids and other algae peaked in September as they had in 1976. Except that the fall increase in diatoms and decrease in blue-greens had begun in November at the plant stations but not yet at the reference stations, the abundance changes in the two sets of stations were directionally similar in 1977.

No dissimilarities attributable to plant operation have been revealed by this method of analysis.

Inner-Outer Graphical Comparisons: Numbers of Forms

In this section the term "forms" includes organisms identified to species (e.g. *Melosira granulata*), organisms identified only to genus (e.g. *Ulothrix* sp. or spp.), and composite groups of unidentified organisms (e.g. Flagellates).

Data on the numbers of phytoplanktonic forms in collections from the Cook Plant region in the years 1971 through 1975 have been presented and discussed by Ayers, Southwick, and Robinson (1977); Ayers (1978) extended the data and discussions to include 1970 and 1976; for the most part the tabulated data in those reports are not repeated here. This section concerns

itself with extending the previous tabulations, figures, and discussions to include the seasonal surveys of 1977. Numbers of forms are listed in each station collection in Appendix B.

As was done in the reports cited, the data on numbers of forms present in 1977 are stratified by three depth zones and inner (treatment) and outer (control) station groups. Stations along, or less than two miles north or south of, a central transect extending perpendicular to shore from the Cook Plant are defined as inner stations which might be affected by plant operation. Stations 2 miles or more north or south of the plant are defined as north and south reference stations or, lumped together, as outer stations. Zero to 8 m depths are designated "Zone 0"; 8 to 16 m as "Zone 1"; and 16 to 24 m as "Zone 2." For each depth zone there are inner and outer station groups. The depth zones and station groups used are:

Depth Zone	Depth Range	Inner Station Group	Outer Station Group
0	0 to 8 m	DC-0 DC-1 NDC-.5-0 NDC-.5-1 NDC-.5-2 NDC-1-0 NDC-1-1 SDC-.5-0 SDC-.5-1 SDC-.5-2 SDC-1-0 SDC-1-1	NDC-2-0 NDC-2-1 NDC-4-0 NDC-4-1 NDC-7-1 SDC-2-0 SDC-2-1 SDC-4-0 SDC-4-1 SDC-7-1
1	8 to 16 m	DC-2 NDC-1-2 SDC-1-2	NDC-2-3 NDC-7-3 SDC-2-3 SDC-7-3
2	16 to 24 m	DC-3 DC-4	NDC-4-3 NDC-7-5 SDC-4-3 SDC-7-5

Mean numbers of forms, the associated standard errors, and numbers of

observations have been computed and are given in Table 4.

TABLE 4. Means, standard errors, and numbers of observations of phytoplankton forms by seasons, depth zones, and inner and outer station groups in Cook Plant seasonal surveys 1977. Previous years are reported by Ayers, Southwick, and Robinson (1977) and Ayers (1978).

1977		14 April	13 July	14 October
Zone 0, Inner				
	Mean	57.17	57.33	66.50
	S. E.	2.74	4.86	3.91
	N	12	12	12
Outer				
	Mean	51.60	54.00	63.10
	S. E.	1.63	6.78	4.84
	N	10	9	10
Zone 1, Inner				
	Mean	57.67	42.67	68.00
	S. E.	9.17	5.33	6.43
	N	3	3	3
Outer				
	Mean	54.00	48.25	71.25
	S. E.	6.37	3.04	9.76
	N	4	4	4
Zone 2, Inner				
	Mean	61.00	42.00	61.50
	S. E.	4.00	2.00	0.50
	N	2	2	2
Outer				
	Mean	46.75	40.50	45.50
	S. E.	5.44	1.33	2.85
	N	4	4	4

Time plots of mean numbers of forms by seasons, depth zones, and inner and outer station groups are presented in Figure 5. Also included in the figure are, for each year, three-seasonal averages of mean numbers of forms at inner and outer stations; these are plotted in July of each year and are connected

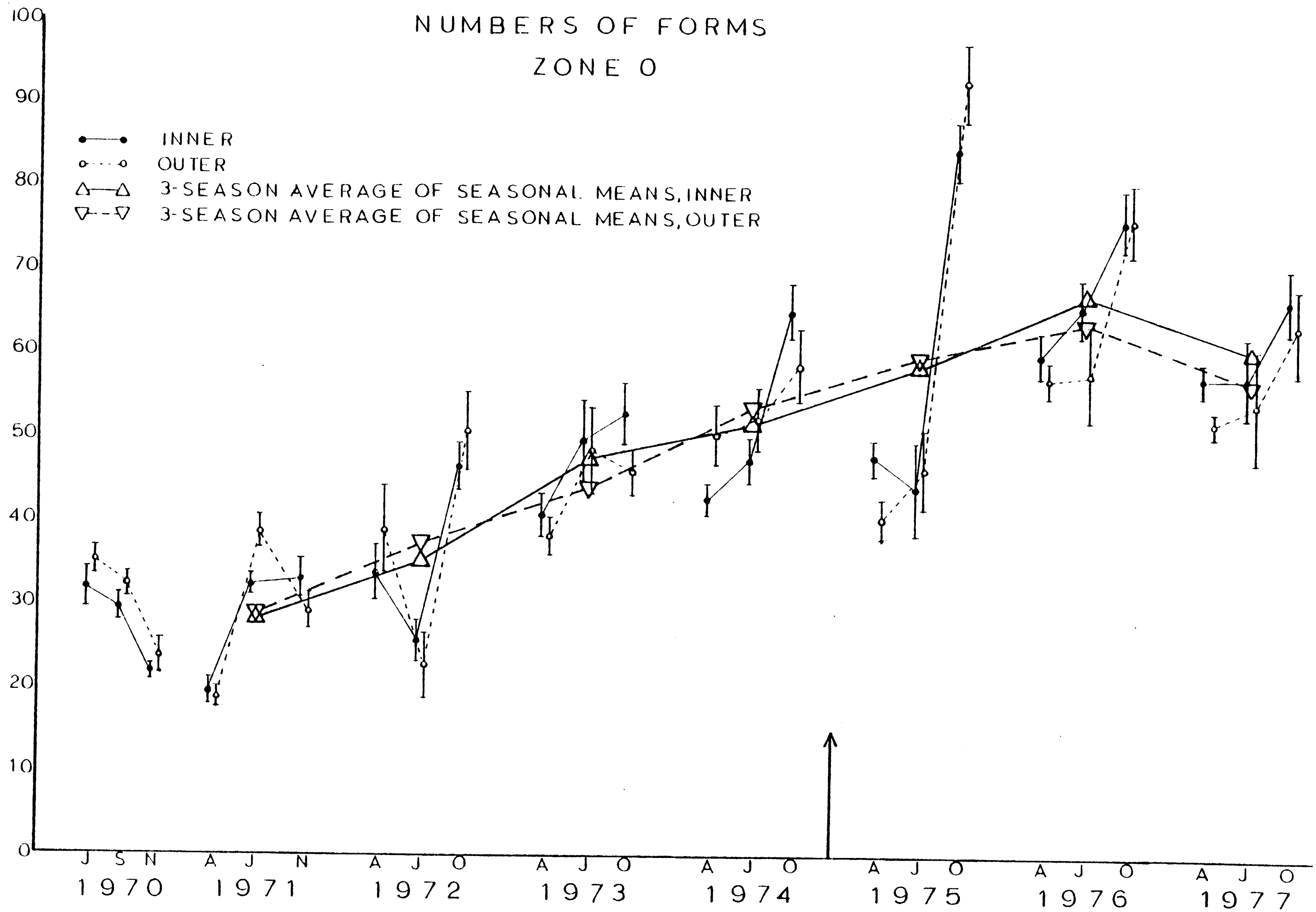

FIG. 5A. Mean numbers of phytoplankton forms in Zone 0 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 4 for numbers of observations.

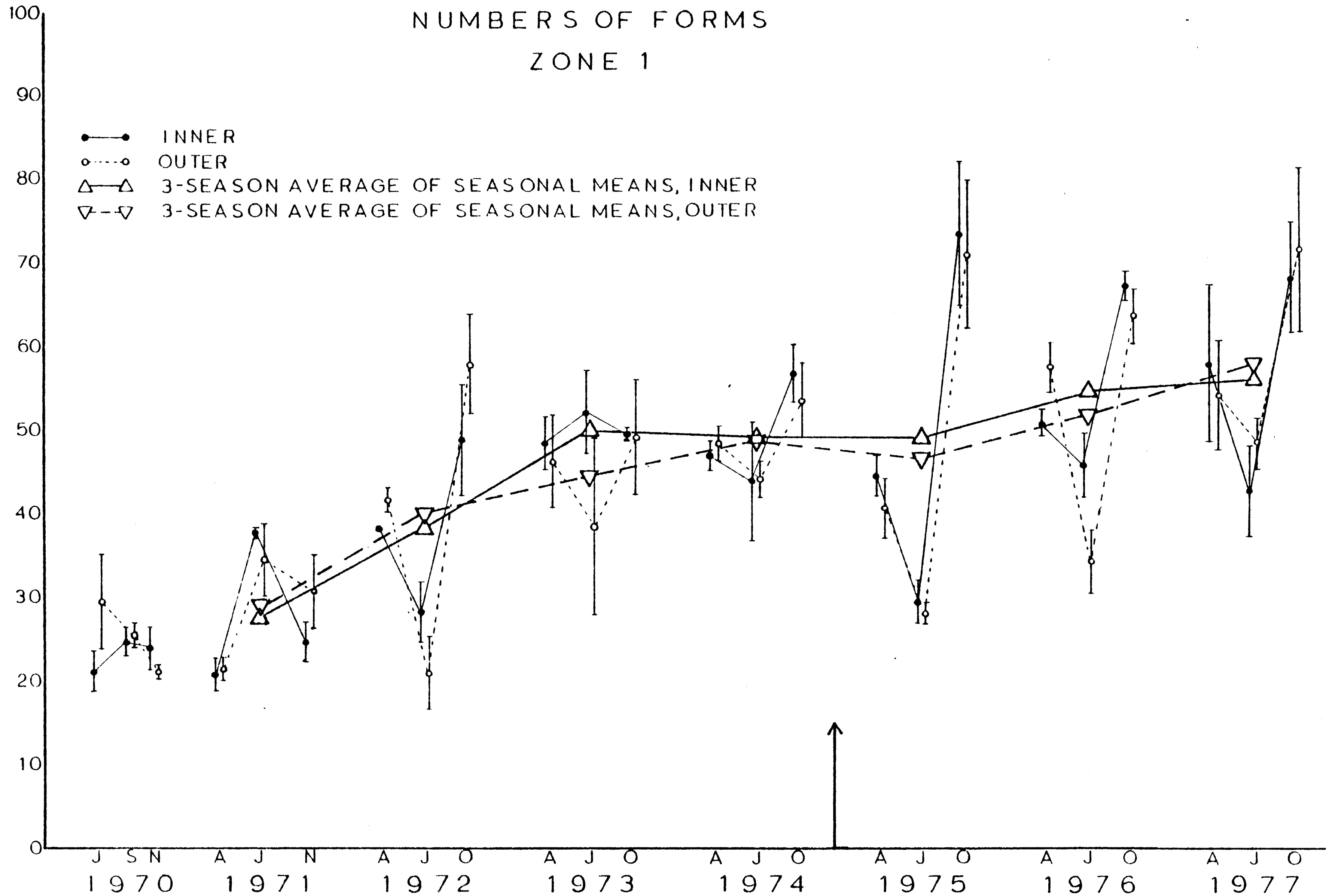

FIG. 5B. Mean numbers of phytoplankton forms in Zone 1 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 4 for numbers of observations.

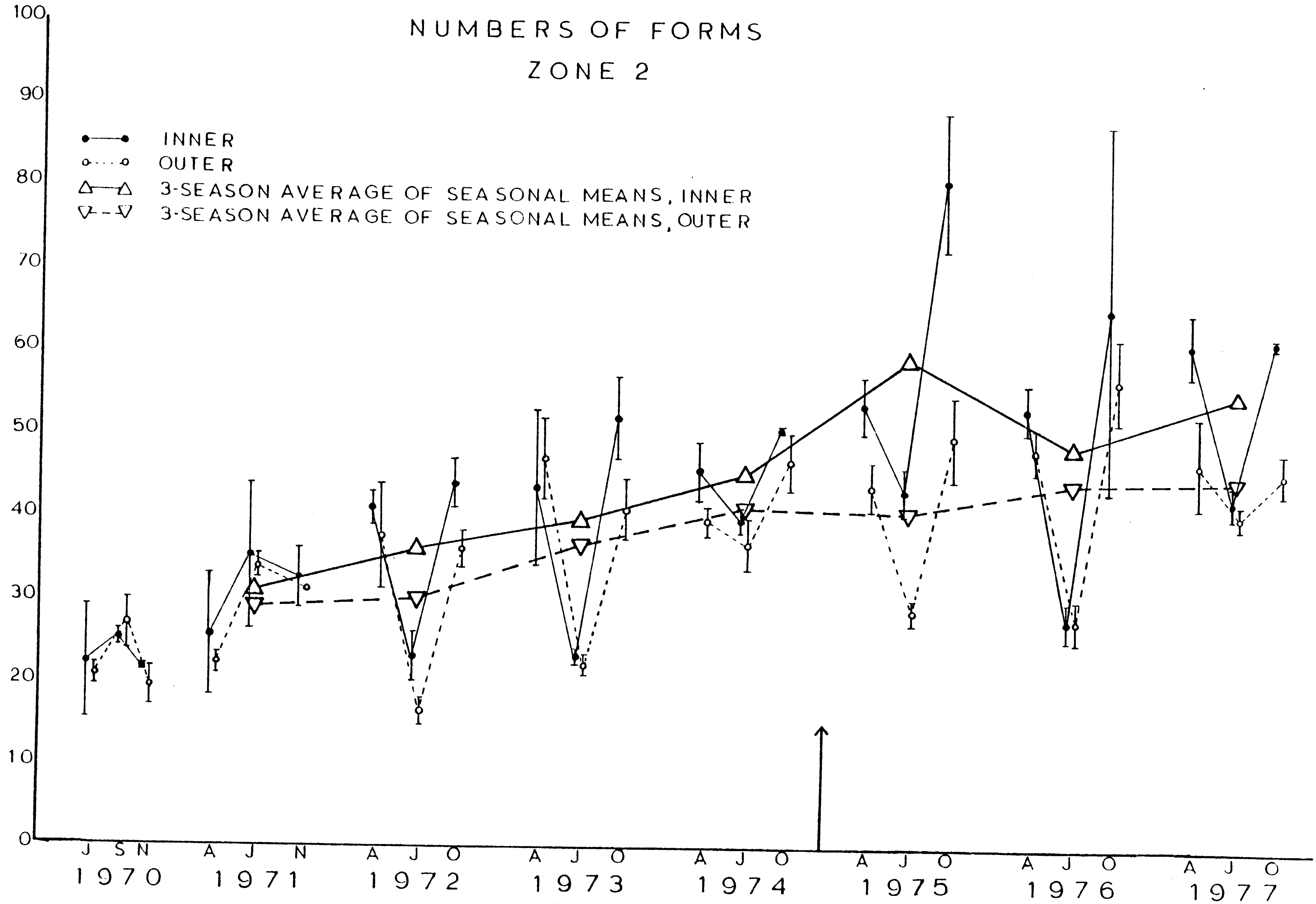

FIG. 5C. Mean numbers of phytoplankton forms in Zone 2 in spring, summer, and fall in inner and outer station groups. The vertical bars show the standard error. See Table 4 for numbers of observations.

from year to year by a solid line for inner stations and a dashed line for outer stations. Such averages for 1970 are not given because only summer and fall were surveyed.

The three-seasonal averages of numbers of forms in 1977 are: Zone 0, inner 60.3, outer 56.2; Zone 1, inner 56.1, outer 57.8; Zone 2, inner 54.8, outer 44.3. Ayers (1978) gives the values for 1971 through 1976.

The annual curves of mean numbers of forms in Figure 5 show substantial degrees of parallelism, indicating that the numbers of forms in inner and outer station groups have in general varied in the same directions from season to season in each year.

In Zone 0 the positions of the annual curves on the graphs and the three-seasonal averages indicate steadily rising tendencies from 1971 through 1976 with a small decrease in 1977. In Zone 1 the curve positions and averages show a tendency to plateau in 1973 through 1975 with increases in 1976 and 1977. In Zone 2 the curve positions and averages for the outer stations show a slow increase in numbers of forms; the inner stations of this zone well off shore show an overall tendency for increase and for there to be more forms at these stations than at the outer ones, conditions which have been true since 1971.

The tendency for increase in numbers of phytoplankton forms in Cook Plant collections since 1971 is consistent with the observations of Stoermer and Yang (1969, pp. 209 and 211) that phytoplankters have been introduced into Lake Michigan in recent decades and that one of the effects of nutrient enrichment from man's activities has been to make the planktonic environment more accessible to forms that find their primary habitat in benthic assemblages.

There is no convincing evidence from this analysis that operation of the Cook Plant since 1975 has had any effect on the local phytoplankton community,

instead the increases in form numbers at the inner and outer station groups appear to be an effect of the lake's eutrophication process.

Inner-Outer Graphical Comparisons: Diversity Indices

Cook Plant species diversity data for the years 1971 through 1976 have been presented and discussed by Ayers, Southwick, and Robinson (1977) and Ayers (1978). The tabulated data in those reports are for the most part not repeated here. This section is concerned with extending the previous discussions, tabulations, and figures to include the major surveys carried out in 1977.

As was done in the report cited above, the diversity index data have been stratified by three depth zones and by inner treatment stations (near the plant) and outer control or reference stations groups. The diversity index used is, as previously, that of Wilhm and Dorris (1968):

$$\bar{d} = -\sum_{i=1}^{S} (n_i/n) \log_2 (n_i/n)$$

where S is the number of species, n is the total number of phytoplankton in cells/ml, n_1 is the number of phytoplankton of the i^{th} species.

Mean diversity indices and associated standard errors for each depth-zone-station-group combination in 1977 have been computed and are presented in Table 5. In Figure 6 the surveys of 1977 have been added at the end of the time plots of diversity indices and standard errors which were presented by Ayers (1978).

TABLE 5. Means, standard errors, and numbers of observations of phytoplankton diversity indices by seasons, depth zones, and inner or outer station groups in Cook Plant major surveys during operational 1977. Previous years are reported in Ayers, Southwick, and Robinson (1977) and Ayers (1978). The diversity index used is that of Wilhm and Dorris (1968) based on log 2. Standard errors are computed only when the number of observations is two or more.

1977		14 April	13 July	14 October
Zone 0, Inner				
	Mean	4.24	3.92	4.06
	S. E.	0.11	0.08	0.22
	N	12	12	12
Outer				
	Mean	4.23	3.84	3.92
	S. E.	0.08	0.08	0.13
	N	10	9	10
Zone 1, Inner				
	Mean	4.19	3.73	3.67
	S. E.	0.08	0.16	0.42
	N	3	3	3
Outer				
	Mean	4.13	3.44	3.54
	S. E.	0.28	0.21	0.34
	N	4	4	4
Zone 2, Inner				
	Mean	4.18	3.29	3.19
	S. E.	0.13	0.21	0.40
	N	2	2	2
Outer				
	Mean	4.06	3.73	2.84
	S. E.	0.20	0.13	0.20
	N	4	4	4

In Figure 6 the annual curves of mean diversity indices generally show substantial degrees of parallelism between inner and outer station groups, though parallelism was poor in all zones in 1971 and 1972, in Zone 0 in 1974, and in Zone 1 in 1970 and 1973. Parallelism between the curves for inner (treatment) and outer (control) stations indicates that changes in diversity

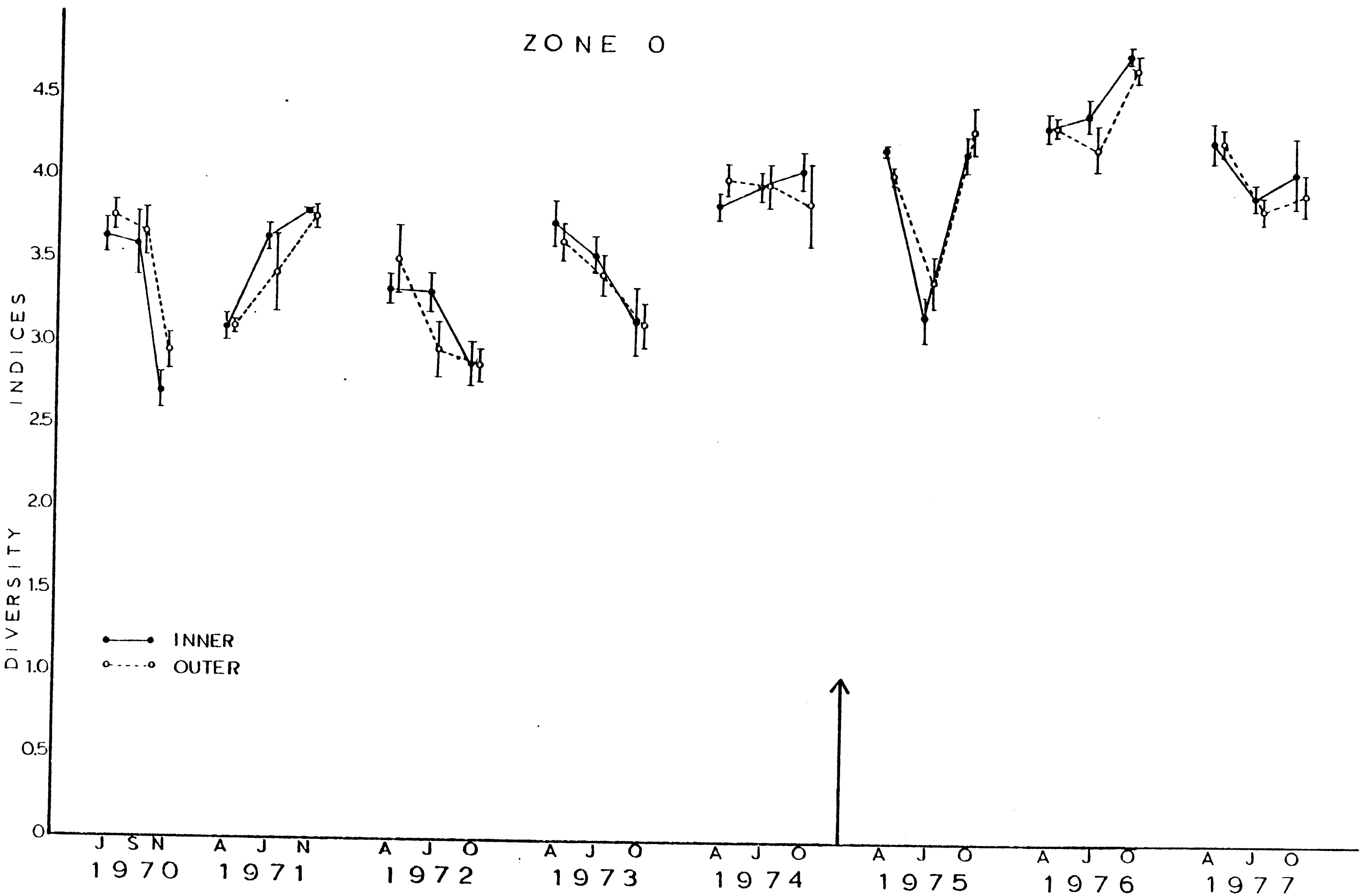

FIG. 6A. Mean diversity indices in Zone 0 by spring, summer, and fall seasons and inner and outer station groups in 1970-1977. The vertical bars show the standard errors. See Table 5 for numbers of observations.

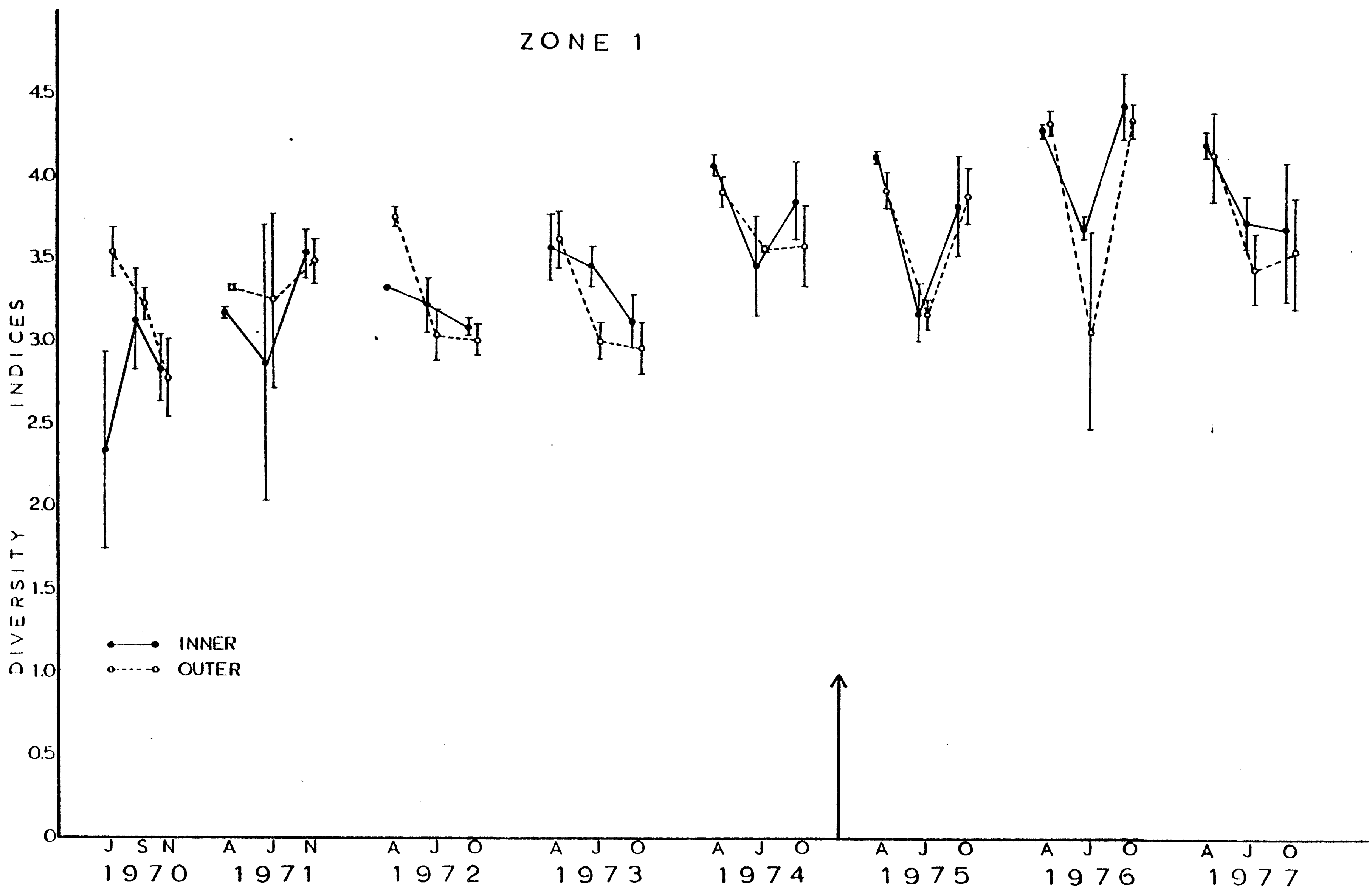

FIG. 6B. Mean diversity indices in Zone 1 by spring, summer, and fall seasons and inner and outer station groups in 1970-1977. The vertical bars show the standard errors. See Table 5 for numbers of observations.

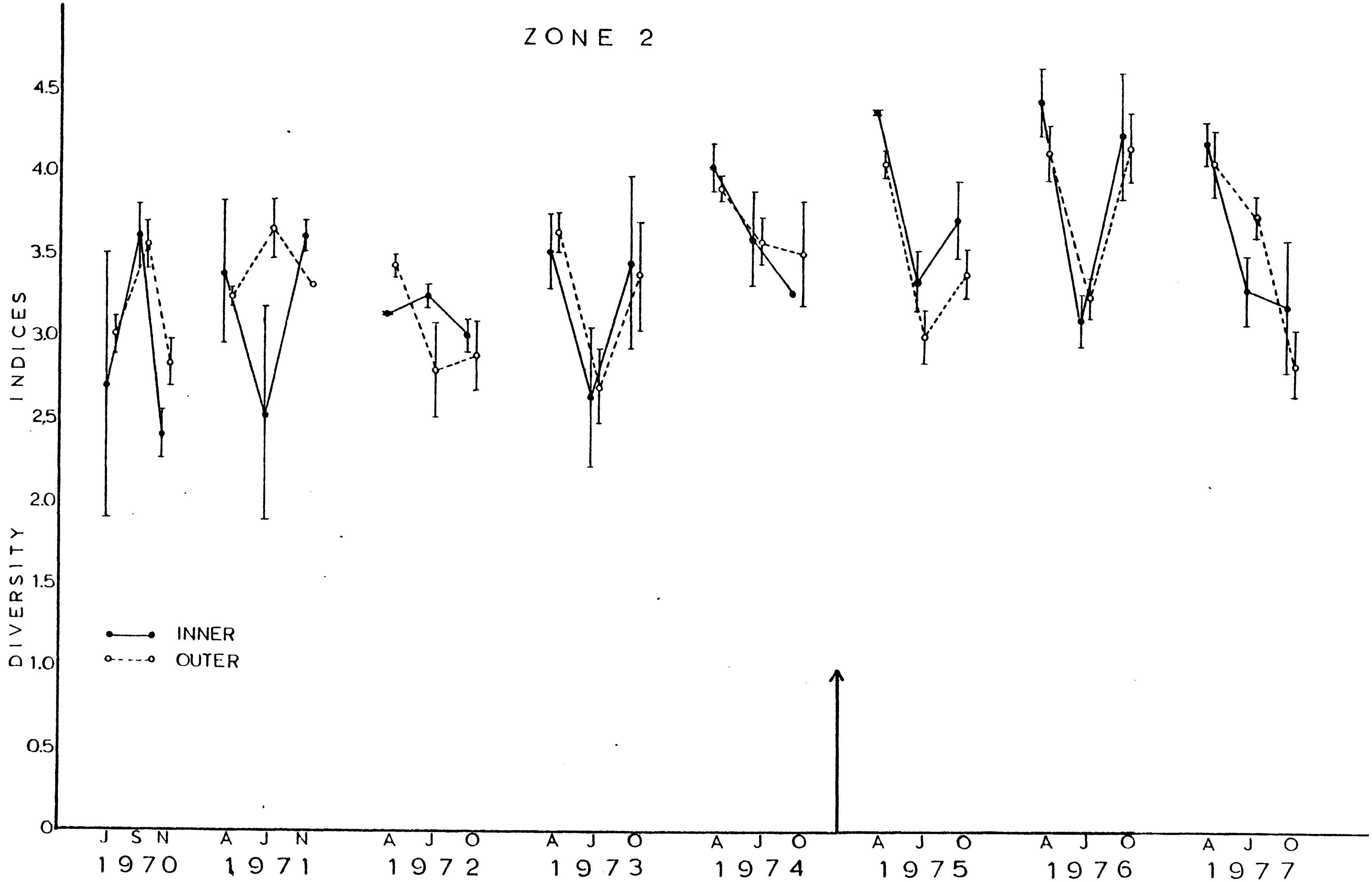

FIG. 6C. Mean diversity indices in Zone 2 by spring, summer, and fall seasons and inner and outer station groups in 1970-1977. The vertical bars show the standard errors. See Table 5 for numbers of observations.

from season to season were the same in both sets of stations. Parallelism of the curves for inner and outer station groups in the operational years 1975 through 1977 has been as good as or better than in the preoperational years.

The placement of annual curves on the graphs shows in all zones either a trend toward increasing diversity from 1972 through 1976 with no increase from 1976 to 1977 or (alternatively) an increase from 1972 through 1974 with a horizontal trend since that year.

The meaning of these two trend possibilities is not now clear. Stoermer and Yang (1969, p. 212) point out that in Lake Michigan there has been a trend for diversity to increase with increasing eutrophication, rather than to decrease as might be expected from theory; if the lower data from 1977 are within normal annual variation, then increase due to eutrophication may be continuing. Alternatively, if the efforts toward reduction of phosphorus input to the lake are beginning to have effect, the upward trend due to eutrophication may be being halted. Data from additional years will be needed to clarify the question.

There is no evidence from our diversity studies thus far that operation of the Cook Plant has adversely affected (lowered the diversity of) the local phytoplankton community in the operational years 1975 through 1977. Instead, the phytoplankton community has in the operational years continued to be more diverse than it was in the preoperational years prior to 1974.

<u>Inner-Outer Graphical Comparisons: Phytoplankton Redundancies</u>

Redundancy values are derived from the diversity index of Wilhm and Dorris (1968):

$$\bar{d} = -\sum_{i=1}^{S} (n_i/n) \log_2 (n_i/n)$$

where S is the number of species, n is the total number of phytoplankton in cells/ml, n_i is the number of phytoplankton of the i^{th} species. Diversity as presented here is not the true diversity since not all forms encountered can be identified to the species level. Therefore, this diversity must be viewed with caution. However, since these diversities do mean something about community structure they will be used to illustrate changes occurring within the phytoplankton population from year to year and for the derivation of redundancies.

Redundancy is a measure of the dominance of one or a few species within a given population. As presented by Wilhm and Dorris (1968) it is:

$$r = \frac{\bar{d}_{max} - \bar{d}}{\bar{d}_{max} - \bar{d}_{min}}$$

where $\bar{d}$ is the observed diversity as calculated above, $\bar{d}_{max}$ is the maximum diversity for a particular community, and $\bar{d}_{min}$ is the minimum possible diversity for a particular community. $\bar{d}_{max}$ is calculated using the following equation:

$$\bar{d}_{max} = (1/n)(\log_2 n! - s \log_2 [n/S]!)$$

and $\bar{d}_{min}$ is calculated using the equation:

$$\bar{d}_{min} = (1/n)(\log_2 n! - s \log_2 [n-(S-1)]!)$$

The values of r range between 0 and 1. An r equal to 0 implies that the species encountered in a community each have the same number of cells. An r equal to 1 implies that one species dominates the community of phytoplankton. Since redundancy values are not given in Appendix B, it is necessary to give them here (Table 6). The values for years 1970 - 1976 have been reported by Ayers (1978). Table 6 also presents the means, standard errors, and numbers of observations of redundancies in Cook Plant major surveys during 1977 stratified by seasons, depth zones, and inner and outer station groups. The means and

TABLE 6 . Means, standard errors, and numbers of observations of phytoplankton redundancies by seasons, depth zones, and inner and outer station groups in Cook Plant major surveys during operational 1977.

	14 April 1977	13 July 1977	14 October 1977
Zone 0, Inner Stations			
DC-0	0.236	0.260	0.204
DC-1	0.272	0.338	0.380
NDC-.5-0	0.275	0.400	0.263
NDC-.5-1	0.212	0.350	0.493
NDC-.5-2	0.244	0.309	0.382
NDC-1-0	0.216	0.346	0.298
NDC-1-1	0.250	0.337	0.340
SDC-.5-0	0.416	0.329	0.231
SDC-.5-1	0.274	0.265	0.480
SDC-.5-2	0.346	0.324	0.420
SDC-1-0	0.260	0.342	0.155
SDC-1-1	0.268	0.304	0.324
Mean	0.272	0.325	0.331
S. E.	0.016	0.011	0.031
N	12	12	12
Outer Stations			
NDC-2-0	0.211	0.321	0.253
NDC-2-1	0.254	0.336	0.384
NDC-4-0	0.193	0.400	0.365
NDC-4-1	0.312	0.281	0.388
NDC-7-1	0.230	0.307	0.320
SDC-2-0	0.227	0.334	0.350
SDC-2-1	0.264	0.308	0.272
SDC-4-0	0.318	0.300	0.369
SDC-4-1	0.251	---	0.422
SDC-7-1	0.282	0.349	0.303
Mean	0.257	0.326	0.343
S. E.	0.014	0.012	0.017
N	10	9	10
Zone 1, Inner Stations			
DC-2	0.277	0.289	0.284
NDC-1-2	0.244	0.328	0.541
SDC-1-2	0.314	0.316	0.381
Mean	0.278	0.311	0.402
S. E.	0.020	0.012	0.075
N	3	3	3
Outer Stations			
NDC-2-3	0.227	0.340	0.416
NDC-7-3	0.261	0.317	0.329
SDC-2-3	0.384	0.458	0.479
SDC-7-3	0.255	0.447	0.501
Mean	0.282	0.391	0.431
S. E.	0.035	0.036	0.039
N	4	4	4
Zone 2, Inner Stations			
DC-3	0.287	0.364	0.538
DC-4	0.308	0.426	0.408
Mean	0.298	0.395	0.473
S. E.	0.010	0.031	0.065
N	2	2	2
Outer Stations			
NDC-4-3	0.214	0.341	0.473
NDC-7-5	0.314	0.335	0.525
SDC-4-3	0.261	0.288	0.561
SDC-7-5	0.267	0.254	0.406
Mean	0.264	0.305	0.491
S. E.	0.021	0.021	0.034
N	4	4	4

standard errors are plotted on a time axis in Figure 7.

The plots in Figure 7 show visual evidence of a trend, beginning in 1973, for redundancies to have become somewhat lower since that year. If real, the trend would indicate that there has been a tendency for the species in the community to have become more nearly equally abundant in numbers of individuals.

Perhaps more important is that after 1972 there has been much better parallelism between the annual curves of redundancies at inner and outer station groups, that is, changes in mean redundancies of collections from the two station groups have been much more alike than was the case in the earlier preoperational years. Since it began in the preoperational years and has continued into the operational years, the tendency for improved parallelism is attributed to some cause in the lake itself.

There is nothing in this analysis of phytoplankton redundancies to indicate that the operation of Cook Plant has exerted any adverse impact on the local phytoplankton community.

Inner-Outer Graphical Comparisons: Phytoplankton Abundances By Algal Categories

This section applies the inner-outer graphical analysis method to the abundances (in cells per ml) of ten major categories of phytoplankton and extends previously reported tabulations, figures, and discussions to include the seasonal surveys of 1977. Earlier years have been reported by Ayers, Southwick, and Robinson (1977) and Ayers (1978).

The phytoplankton abundances used are those of total algae and of the nine major algal groups: coccoid blue-greens, filamentous blue-greens, coccoid greens, filamentous greens, flagellates, centric diatoms, pennate diatoms, desmids, and other algae. The use of major algal groups bypasses difficulties stemming from inability to always identify to species, and is justifiable on

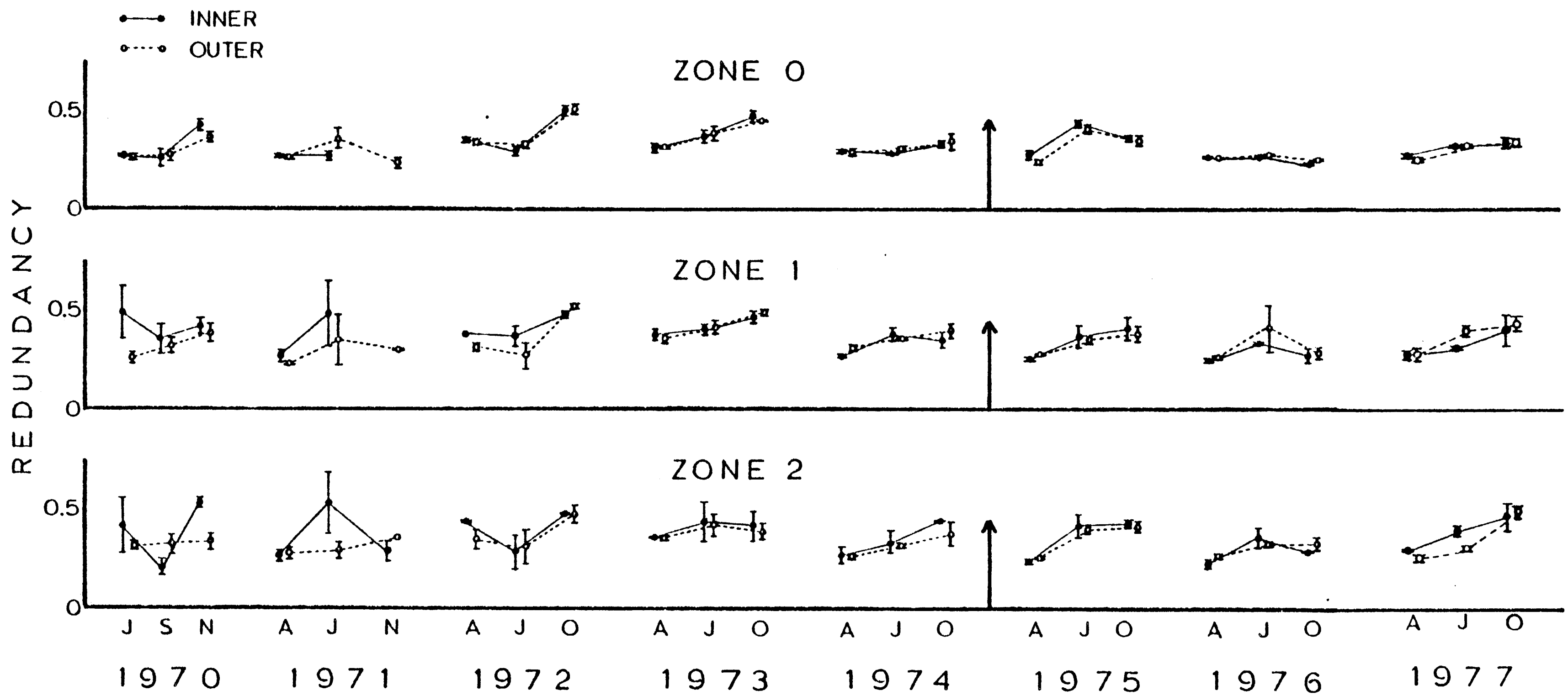

FIG. 7. Mean redundancies of phytoplankton collections from three depth zones in the Cook Plant area, by spring, summer, and fall seasons and inner and outer station groups in 1970-1977. The vertical bars show the standard errors. See Table 6 for numbers of observations.

the basis that members of each individual group have more or less similar functions in the ecosystem.

Table 7 presents, for the seasonal surveys of 1977, the means, standard errors, and numbers of observations of abundances of total algae and the nine major groups of planktonic algae in the three depth zones and the inner and outer station groups. These are graphed with the preceeding years in Figure 8.

Desmids (Fig. 8A) have shown almost no variation in abundance over the entire eight years of the study.

Filamentous green algae (Fig. 8B), which in April 1976 had somewhat increased in abundance in both station groups and in all three depth zones, returned to preoperational levels in July of that year and have remained there ever since.

Other algae (Fig. 8C), increased in abundance in all depth zones and both station groups in 1976 and 1977, but similar abundances had been observed in preoperational years. There is no clear evidence that the recent greater abundances were plant-induced.

Filamentous blue-green algae (Fig. 8D) have been more abundant in all depth zones and both sets of stations in the three operational years. In Zones 0 and 1 increases at the outer stations equalled or exceeded those at the inner stations in all three years. In 1976 and 1977 in Zone 2 July abundances at the inner stations greatly exceeded those at the outer stations. Although these inner stations are in front of the plant, they are offshore stations where the plant's discharge plume is present little if any of the time; the increases at these stations appear more apt to be effects of lake eutrophication than of Cook Plant operation.

Coccoid blue-greens (Fig. 8E), which had been present in small amounts during most of the preoperational surveys, increased notably in October of

TABLE 7. Means, standard errors, and numbers of observations of phytoplankton abundances by seasons, depth zones, and inner and outer station groups in Cook Plant major surveys during 1977. Previous years have been reported by Ayers, Southwick, and Robinson (1977) and Ayers (1978). Units are cells per ml. B-G = blue-greens, Filam. = filamentous.

Zone	Inner, Outer	Coccoid B-G	Filam. B-G	Coccoid greens	Filam. greens	Flagel- lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
14 APRIL 1977											
0	Inner										
	Mean	24.88	37.44	97.97	0.97	2267.10	621.08	1972.60	0.83	113.03	5135.80
	S. E.	24.88	4.01	23.44	0.66	212.96	41.68	201.45	0.59	25.41	437.46
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	53.05	31.33	90.37	1.65	1891.40	488.79	1673.00	0.33	117.92	4347.80
	S. E.	28.59	5.77	31.28	1.13	229.20	77.86	144.52	0.33	23.89	412.23
	N	10	10	10	10	10	10	10	10	10	10
1	Inner										
	Mean	332.70	51.40	66.33	0	1629.30	453.73	1531.00	1.10	72.93	4138.50
	S. E.	252.54	24.09	20.28	0	262.71	115.53	211.33	1.10	24.90	701.19
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	92.85	31.47	50.97	7.87	2319.20	470.90	1464.10	0	101.55	4538.90
	S. E.	85.29	5.49	18.63	4.85	326.49	83.05	98.19	0	21.63	327.78
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	182.40	35.65	76.25	0	1486.40	393.80	1312.30	0	51.40	3538.30
	S. E.	182.40	17.45	21.55	0	27.35	14.10	156.65	0	0	364.80
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	8.30	19.47	34.40	3.32	1017.60	340.72	603.97	0.82	82.90	2111.50
	S. E.	8.30	9.74	17.20	3.32	162.51	44.36	176.37	0.82	54.39	341.22
	N	4	4	4	4	4	4	4	4	4	4

TABLE 7. continued.

Zone	Inner, Outer	Coccoid B-G	Filam. B-G	Coccoid greens	Filam. greens	Flagel-lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
13 JULY 1977											
0	Inner										
	Mean	262.38	240.30	266.39	5.64	609.75	1056.30	896.59	0.56	127.67	3465.60
	S. E.	108.91	69.95	43.44	1.39	78.61	131.27	224.60	0.31	19.59	422.59
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	299.54	231.77	209.64	8.86	550.94	1041.40	717.01	0.56	132.37	3192.00
	S. E.	70.06	144.05	46.42	2.79	99.33	145.48	246.27	0.39	31.59	595.47
	N	9	9	9	9	9	9	9	9	9	9
1	Inner										
	Mean	59.70	77.93	97.27	0.27	160.53	655.23	307.03	2.20	48.07	1408.30
	S. E.	55.57	28.53	45.32	0.27	36.38	127.68	127.68	2.20	14.75	428.34
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	105.62	759.17	212.00	2.90	538.87	858.05	225.47	0.40	112.35	2815.00
	S. E.	44.92	420.69	60.90	1.05	101.05	143.54	33.49	0.23	30.34	493.72
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	281.85	1575.10	392.95	3.35	474.20	624.30	258.70	2.50	127.65	3740.50
	S. E.	132.65	396.25	86.25	1.65	102.80	120.20	82.90	0.80	46.45	358.15
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	86.00	97.62	154.62	2.07	536.97	783.22	245.62	0.42	63.40	2019.90
	S. E.	55.53	49.91	32.65	1.25	81.64	136.10	48.06	0.42	18.66	173.44
	N	4	4	4	4	4	4	4	4	4	4

TABLE 7. continued.

Zone	Inner, Outer	Coccoid B-G	Filam. B-G	Coccoid greens	Filam. greens	Flagel-lates	Centric diatoms	Pennate diatoms	Desmids	Other algae	Total
14 OCTOBER 1977											
0	Inner										
	Mean	2127.00	28.73	252.15	8.57	806.52	442.99	1078.20	1.11	168.71	4913.90
	S. E.	684.04	9.33	37.87	4.50	190.79	71.44	114.06	0.42	21.62	916.77
	N	12	12	12	12	12	12	12	12	12	12
	Outer										
	Mean	1104.40	52.89	223.82	0.66	770.48	932.65	1353.80	1.98	138.74	4579.60
	S. E.	457.04	25.47	45.26	0.66	158.14	387.16	268.27	0.88	45.82	717.80
	N	10	10	10	10	10	10	10	10	10	10
1	Inner										
	Mean	1375.10	11.53	70.73	0	632.27	235.97	436.07	2.20	93.97	2858.00
	S. E.	654.54	3.43	15.79	0	44.40	37.73	92.46	1.10	14.02	724.00
	N	3	3	3	3	3	3	3	3	3	3
	Outer										
	Mean	2295.60	23.20	172.85	1.65	773.05	294.70	530.57	2.08	136.37	4230.10
	S. E.	688.15	7.80	39.42	1.65	21.75	34.09	107.19	1.25	27.25	634.80
	N	4	4	4	4	4	4	4	4	4	4
2	Inner										
	Mean	2468.80	4.95	98.65	0	701.40	194.80	302.60	0.85	137.45	3909.70
	S. E.	1208.72	1.65	38.95	0	31.50	22.40	126.80	0.85	3.45	1427.58
	N	2	2	2	2	2	2	2	2	2	2
	Outer										
	Mean	2805.00	13.25	71.73	0	631.62	174.82	249.97	1.68	45.18	3993.40
	S. E.	774.25	5.24	33.06	0	121.73	61.93	61.06	1.18	8.02	924.00
	N	4	4	4	4	4	4	4	4	4	4

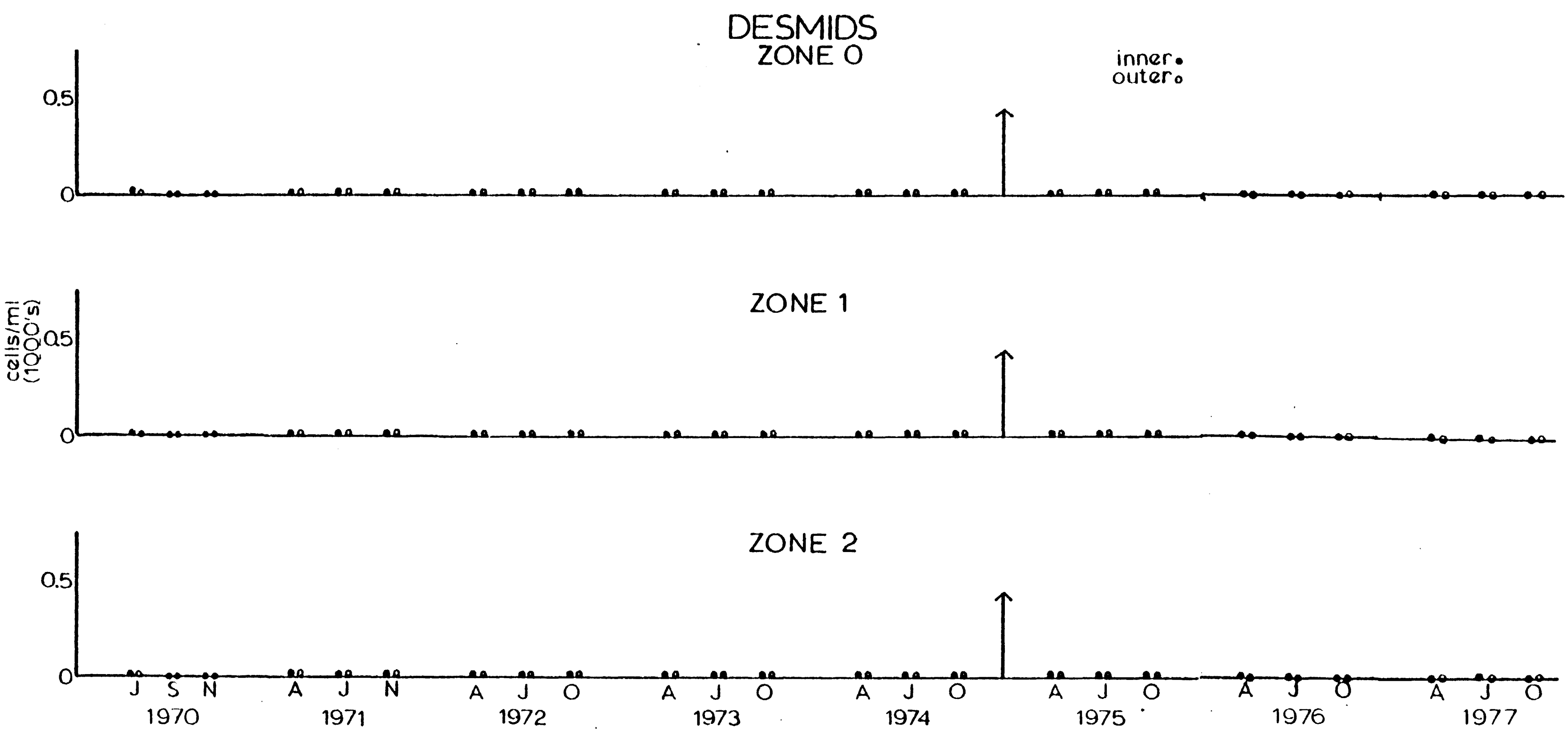

FIG. 8A. Mean abundances of desmids in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. Space does not permit the drawing of standard error bars. See Table 7 for standard errors and numbers of observations.

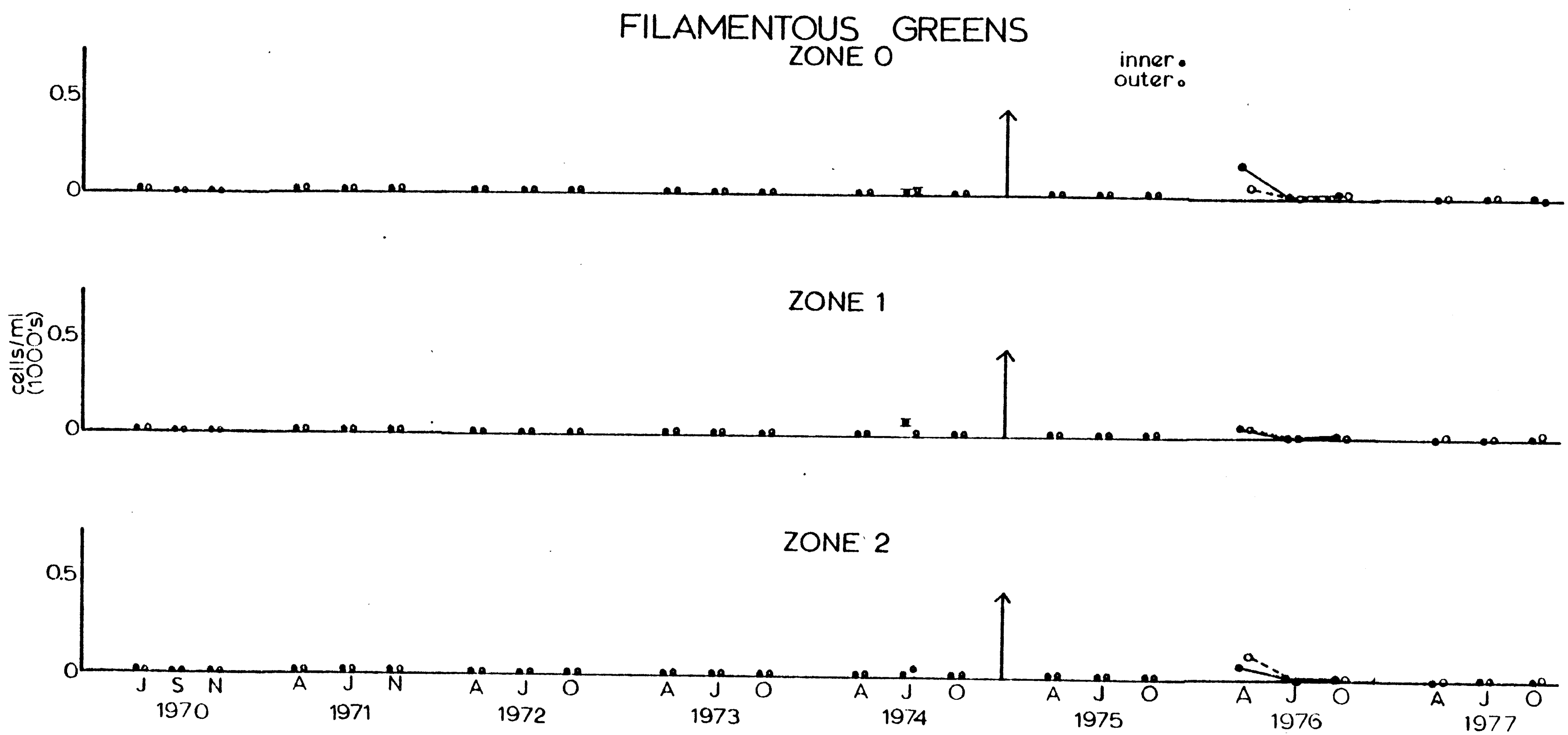

FIG. 8B. Mean abundances of filamentous green algae in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. Space does not permit the drawing of standard error bars. See Table 7 for standard errors and numbers of observations.

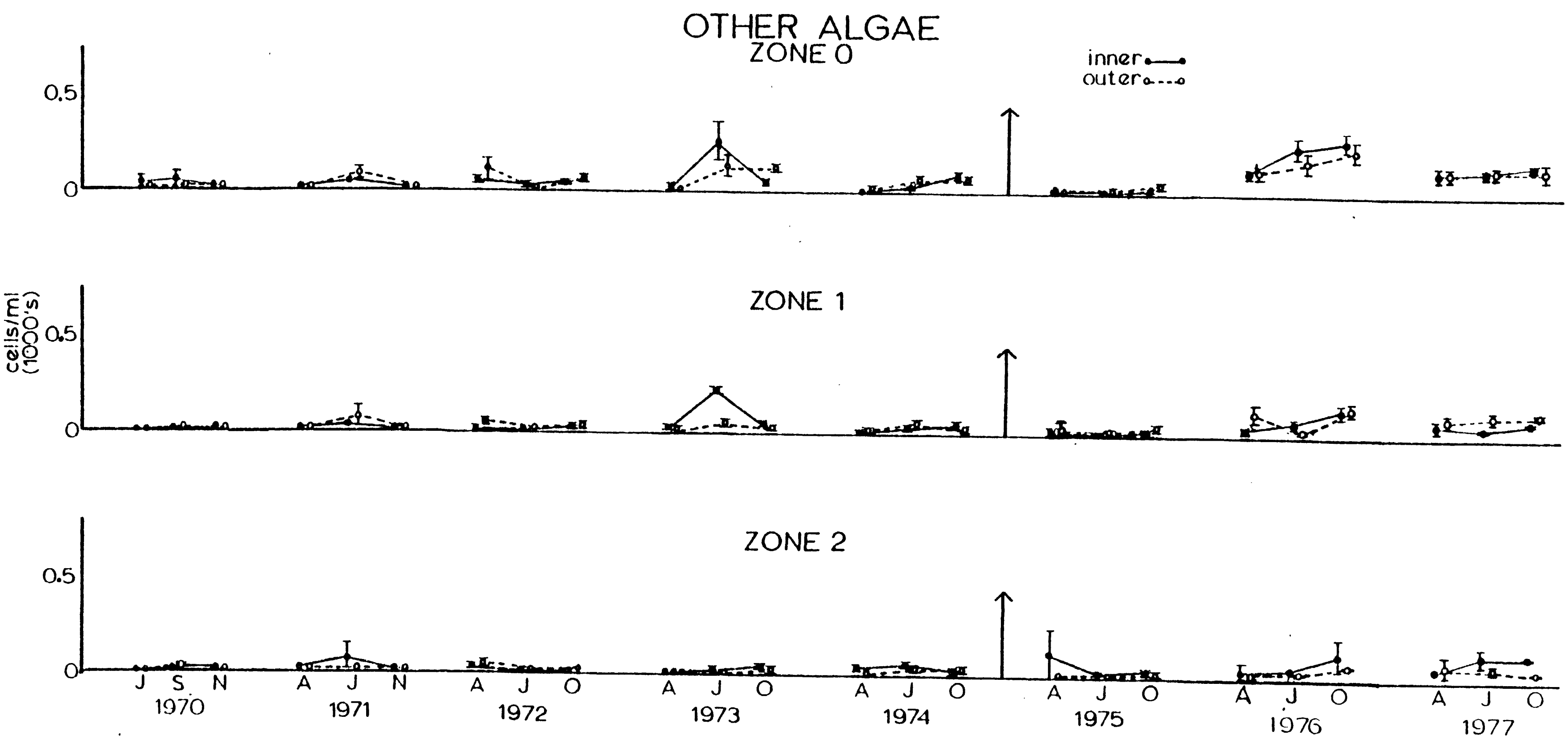

FIG. 8C. Mean abundances of "other algae" in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

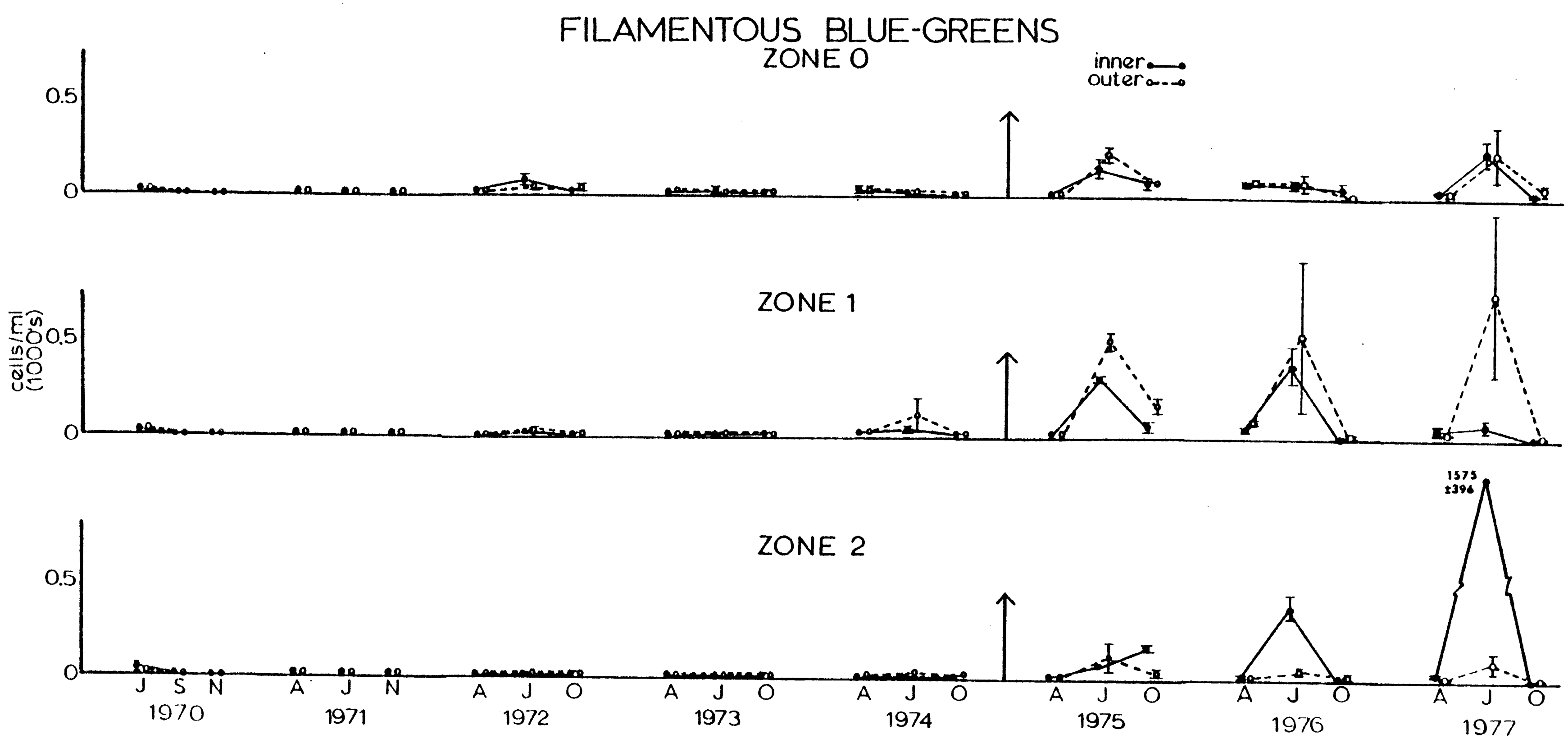

FIG. 8D. Mean abundances of filamentous blue-green algae in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. Where space permits, vertical bars show the standard errors. See Table 7 for numbers of observations and other standard errors.

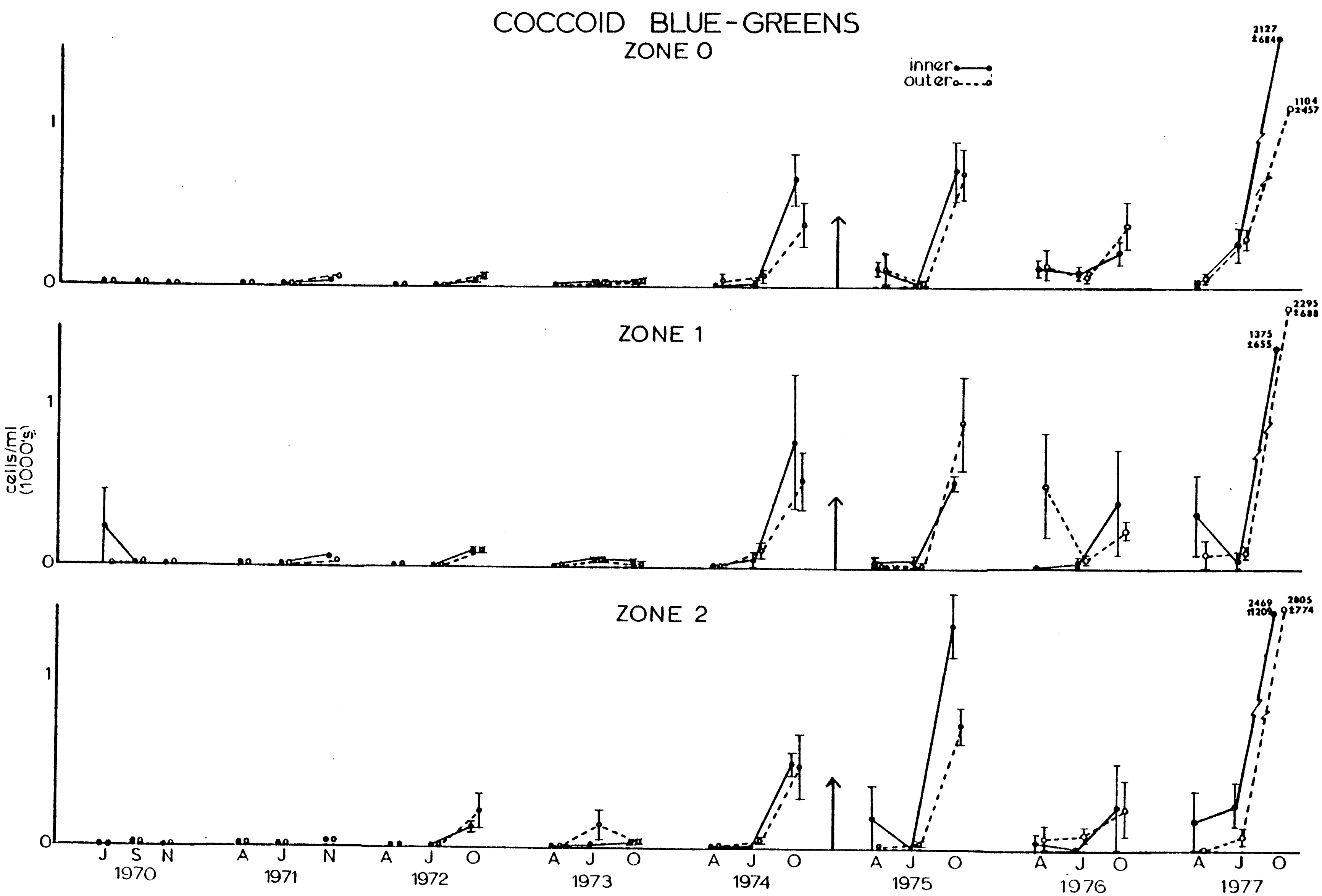

FIG. 8E. Mean abundances of coccoid blue-green algae in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. Vertical bars show the standard errors. See Table 7 for numbers of observations.

preoperational 1974 (due in part to a change in counting method that year) and this pattern has been characteristic in the years since, not so pronounced in 1976, and very pronounced in 1977. It is to be noted that the increases in October 1977 were greater in the outer stations of Zones 1 and 2. Beginning in preoperational 1974 and continuing since, these fall increases are attributed to lake eutrophication, rather than to plant operation.

Coccoid green algae (Fig. 8F) have been present in variable abundances of a few hundred cells per ml in each survey of the study area. In all but one of the operational surveys the abundances of these algae were at levels which had been observed in the preoperational years; the exception was at the inner station group of Zone 2 in July 1977 when abundances were somewhat higher than previously seen. These being offshore stations where the plant plume is not expected, the high of that month is attributed to some lake effect, not plant operation.

Flagellates (Fig. 8G) in both station groups and all three depth zones continued in 1977 the trends of steadily increasing abundances that had been going on since 1971. The trends show no evident relationship to the startup of Cook Plant. We consider them to be effects of eutrophication, and note with interest that Stoermer, Bowman, Kingston, and Schaedel (1974, p. 366) hypothesize that the great abundances of flagellates in Lake Ontario may be related to elevated organic loadings.

Pennate diatoms (Fig. 8H), like the flagellates, have shown in all depth zones and in both station groups steadily rising trends in their abundances. Their spring abundances have been generally increasing since 1973; their summer "crashes" in numbers have not been lower than they attained in preoperational years; and their fall abundances have been generally increasing since 1973. In these conditions among the pennates we see no effect of Cook Plant operation,

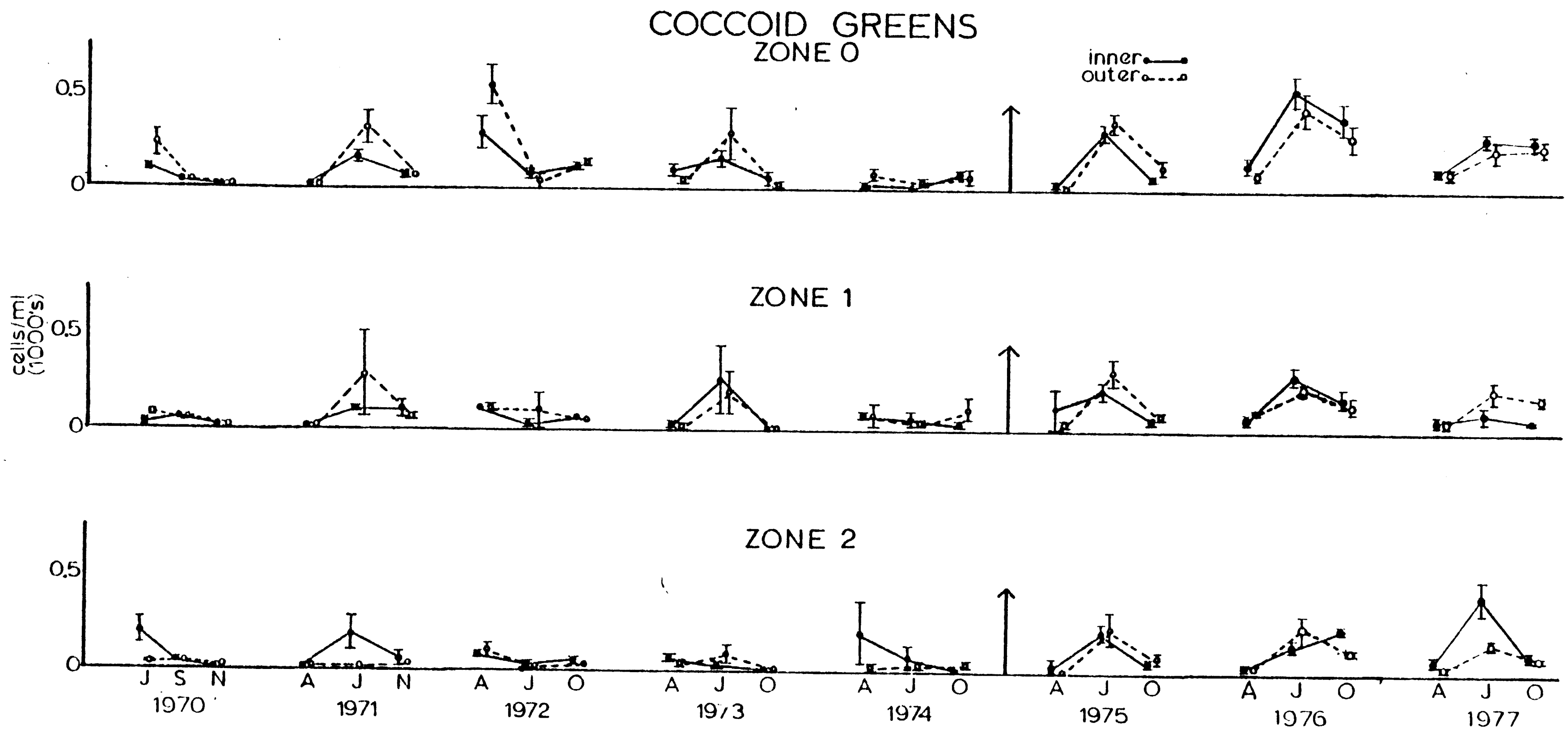

FIG. 8F. Mean abundances of coccoid green algae in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

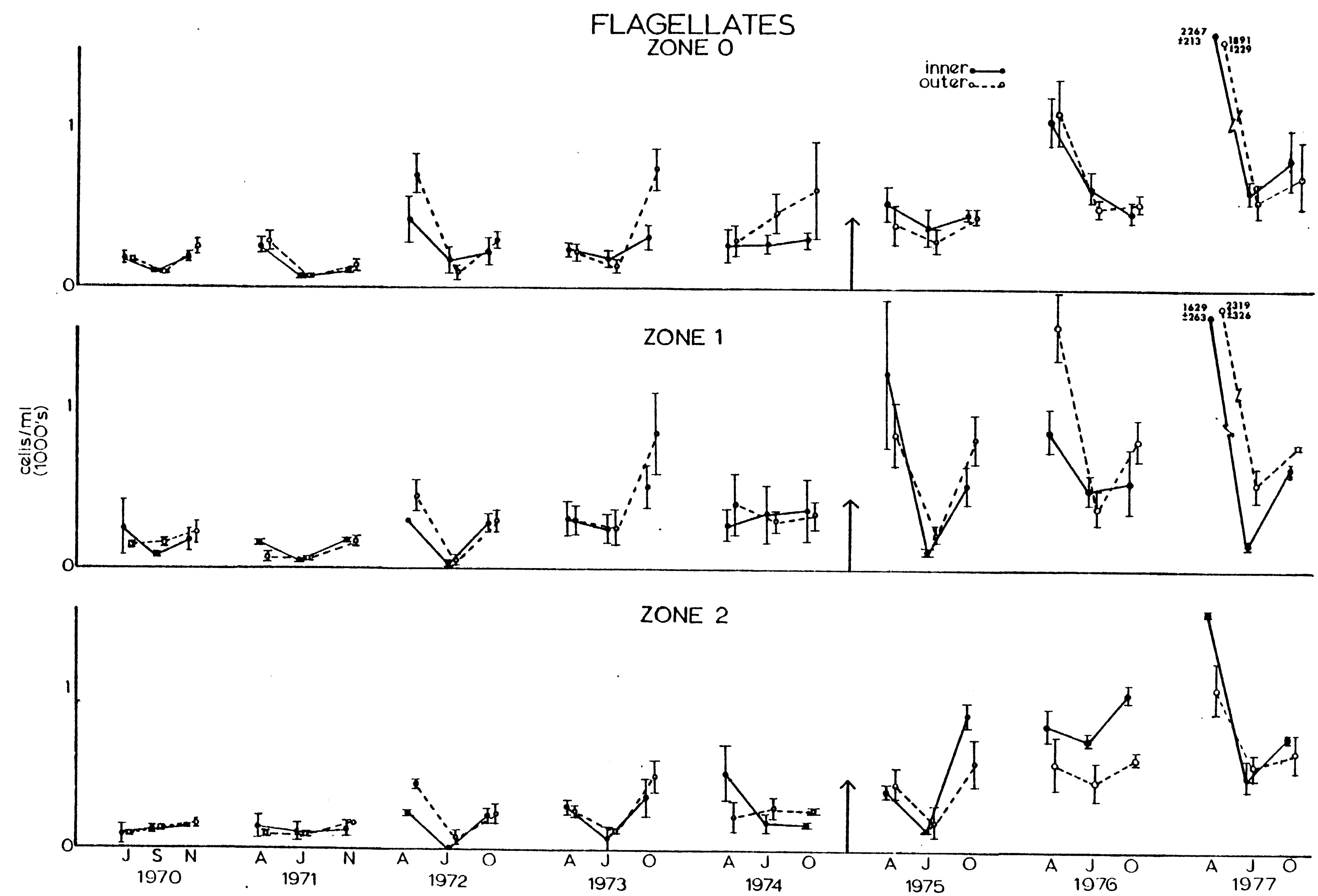

FIG. 8G. Mean abundances of flagellates in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

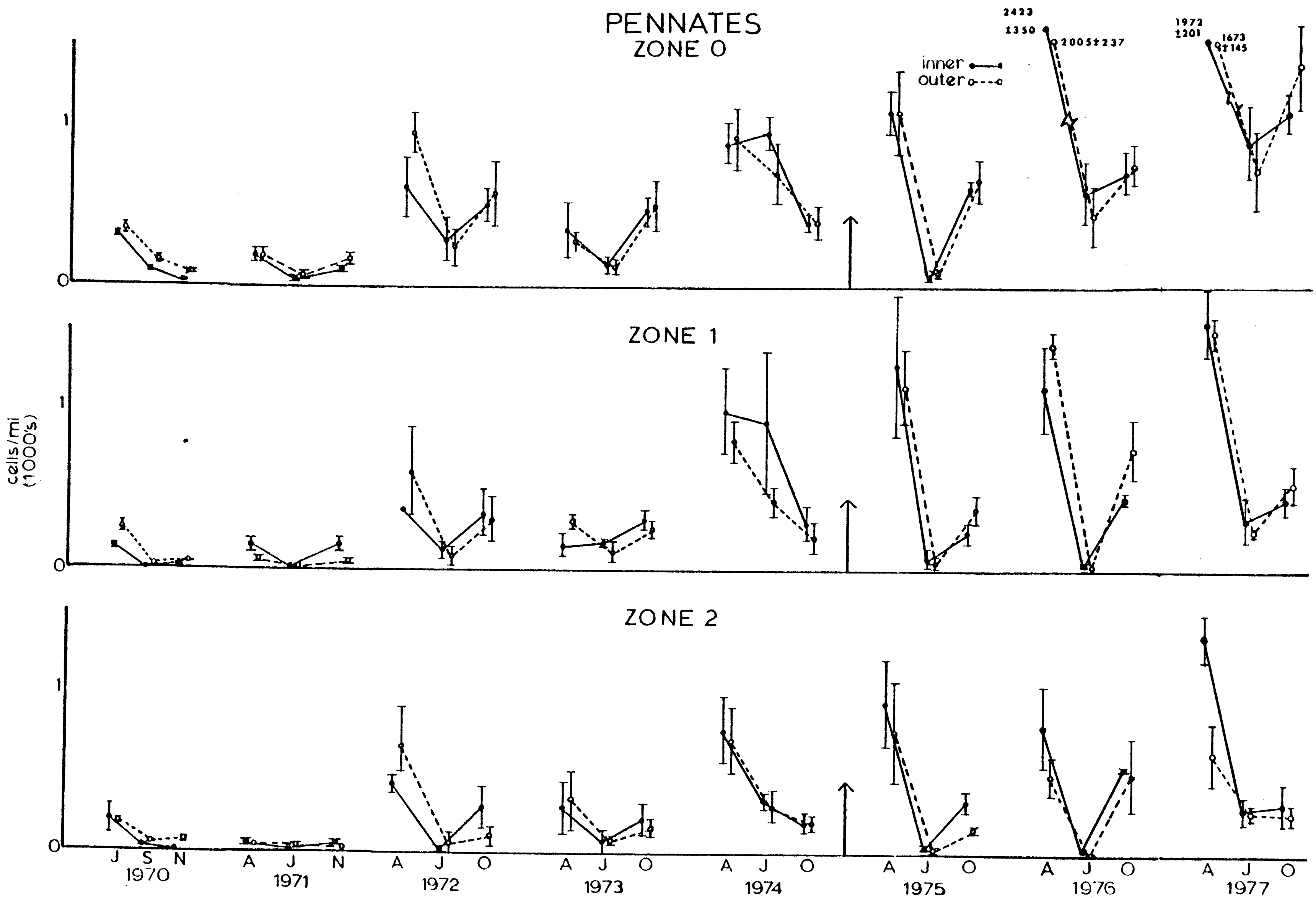

FIG. 8H. Mean abundances of pennate diatoms in Zones 0 - 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

but rather a combination of: (1) increasing nutrient loading; (2) summer epilemnetic silica depletions; and (3) a tolerant group of organisms. Concerning the latter, Stoermer, Bowman, Kingston, and Schaedel (op. cit., p. 365) say: "The elements of the phytoplankton flora which are common to both Lake Ontario and the upper lakes are those apparently eurytopic species such as *Asterionella formosa* [pennate], *Fragilaria crotonensis* [pennate], *Ankistrodesmus falcatus* [other], *Botryococcus braunii* [coccoid green], *Cryptomonas erosa* [flagellate] etc. which enjoy almost universal distribution in both oligotrophic and eutrophic lakes." We note that the pennates *Fragilaria crotonensis*, *Tabellaria fenestrata*, and *T. fenestrata* v. *intermedia* have been frequent dominant or codominant forms in Cook Plant collections and consider this to be in harmony with the quotation above and with the paragraph on page 225 of the work cited where *Tabellaria fenestrata* is called common, widely distributed, and tolerant.

Centric diatoms (Figs. 8I,J,K) have varied widely in abundance during the period of study. Abundance variations at inner and outer stations have been directionally similar within each year but the annual patterns have been inconsistent from year to year. The expected summer minimum did not occur in any zone in 1977 nor in Zones 0 or 1 in 1973. Fall recoveries in abundance did not occur in 1970, 1971, 1974, 1977, nor (except for the inner stations of Zone 2) in 1973. No clear effect of Cook Plant operation is discernable in the data on centric diatoms.

Total algae (Figs. 8L,M,N) have, in all three depth zones and in both inner and outer station groups, exhibited steadily rising abundances since 1974; in Zone 2 the trend in abundance has been steadily upward since 1971. In Zone 0 mean abundance levels in 1972 and 1973 were higher than a trend line from 1971 to 1974; in Zone 1 mean abundances in 1973 were higher than a trend

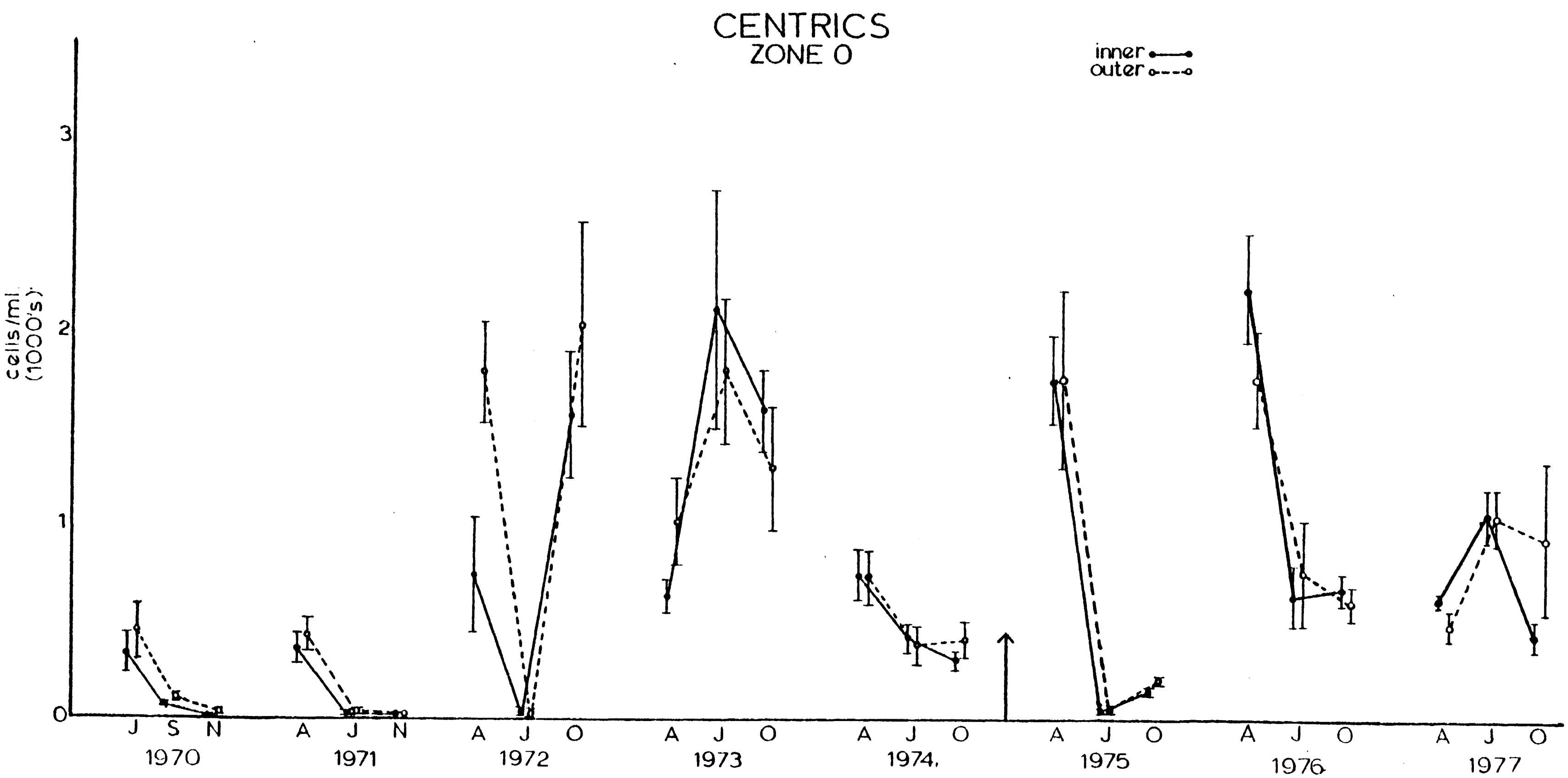

FIG. 8I. Mean abundances of centric diatoms in Zone 0 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

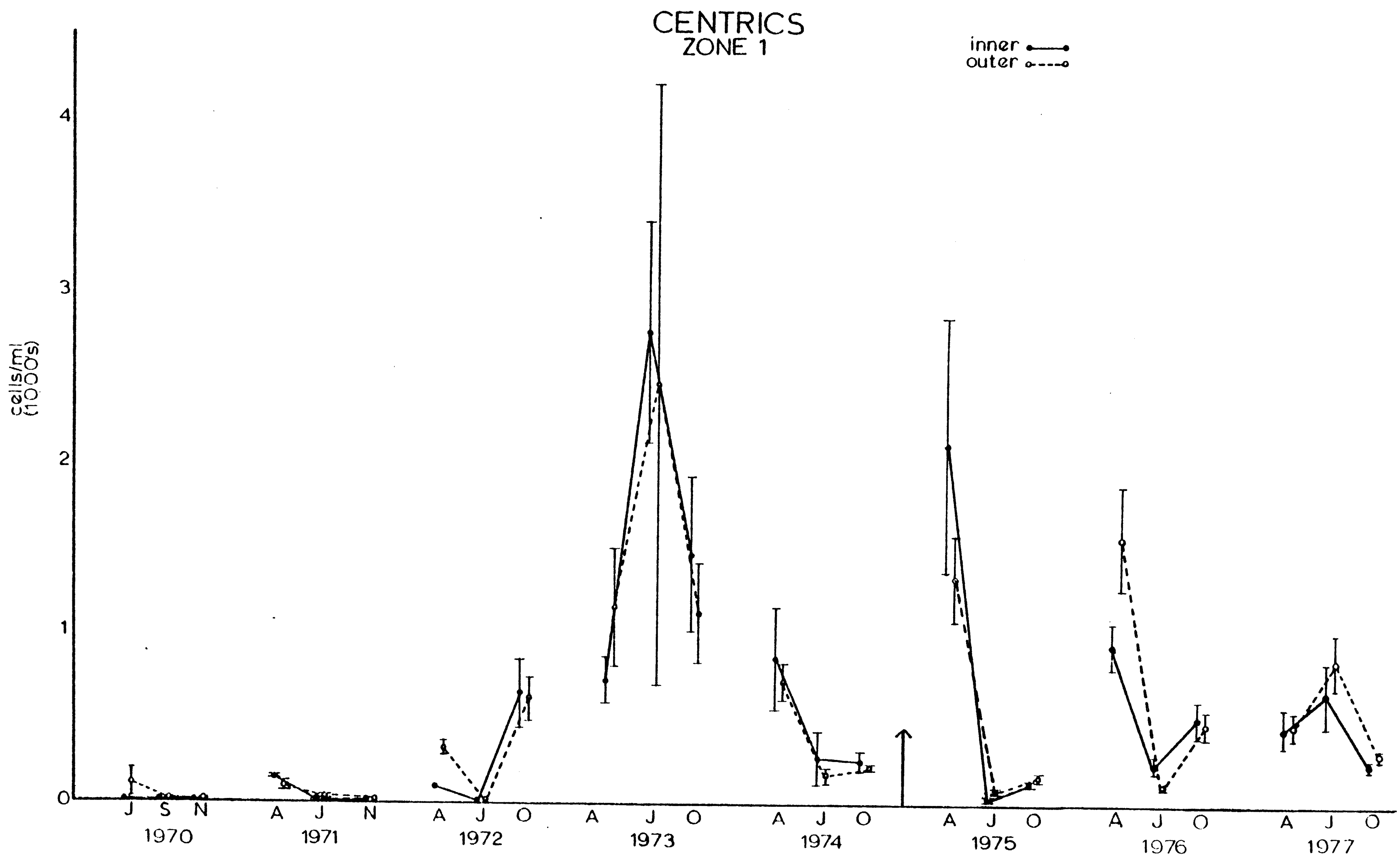

FIG. 8J. Mean abundances of centric diatoms in Zone 1 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

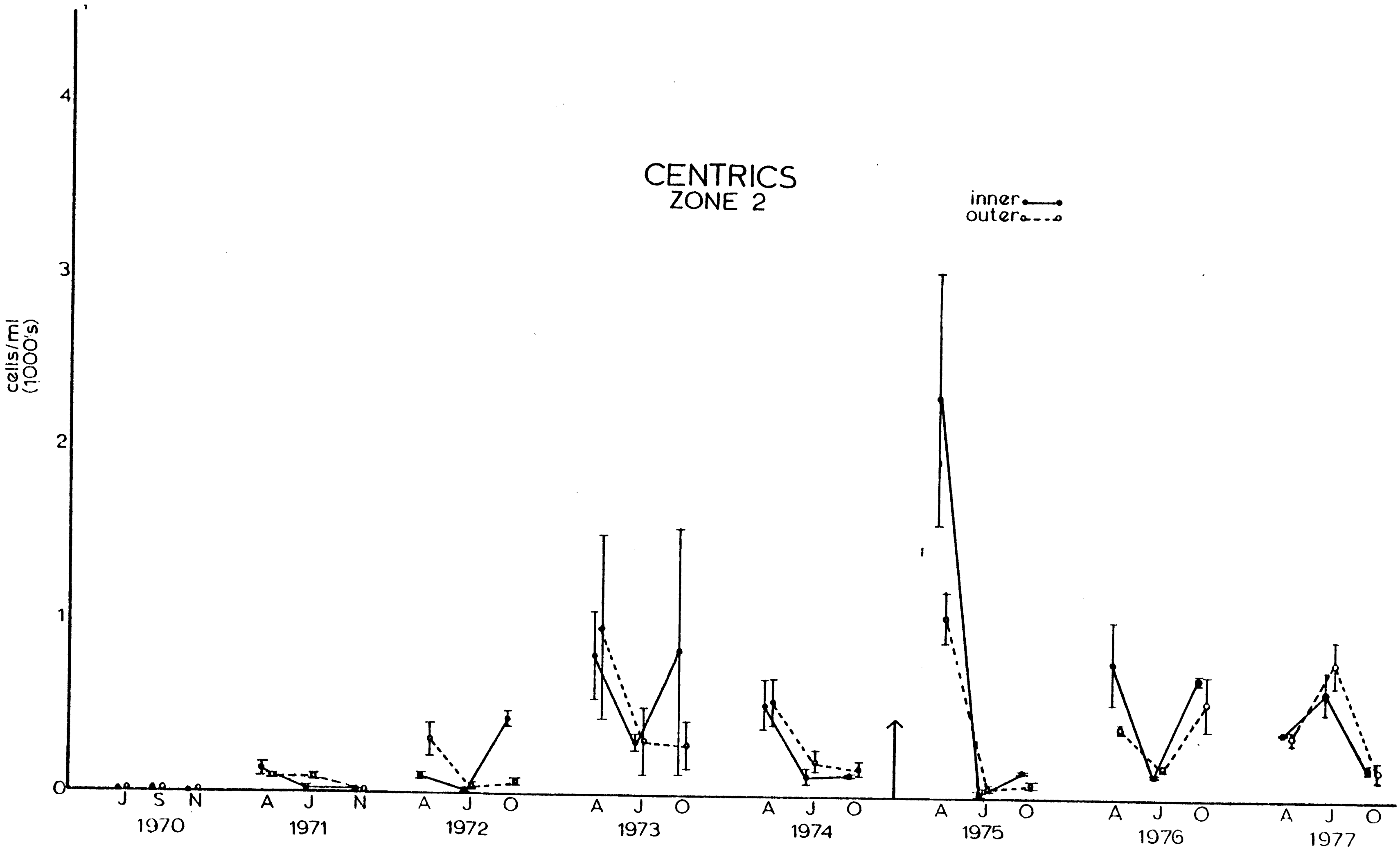

FIG. 8K. Mean abundances of centric diatoms in Zone 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

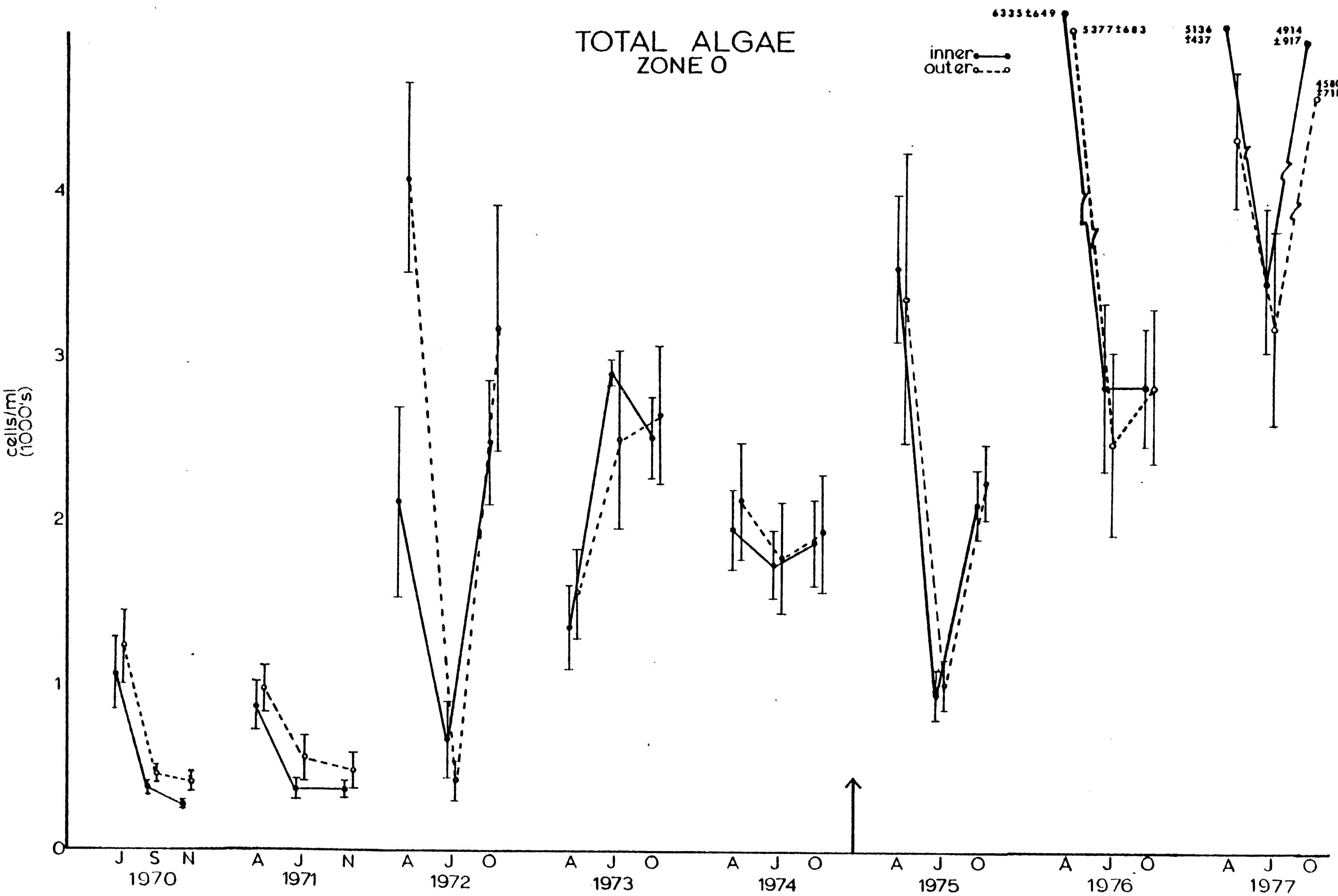

FIG. 8L. Mean abundances of total algae in Zone 0 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

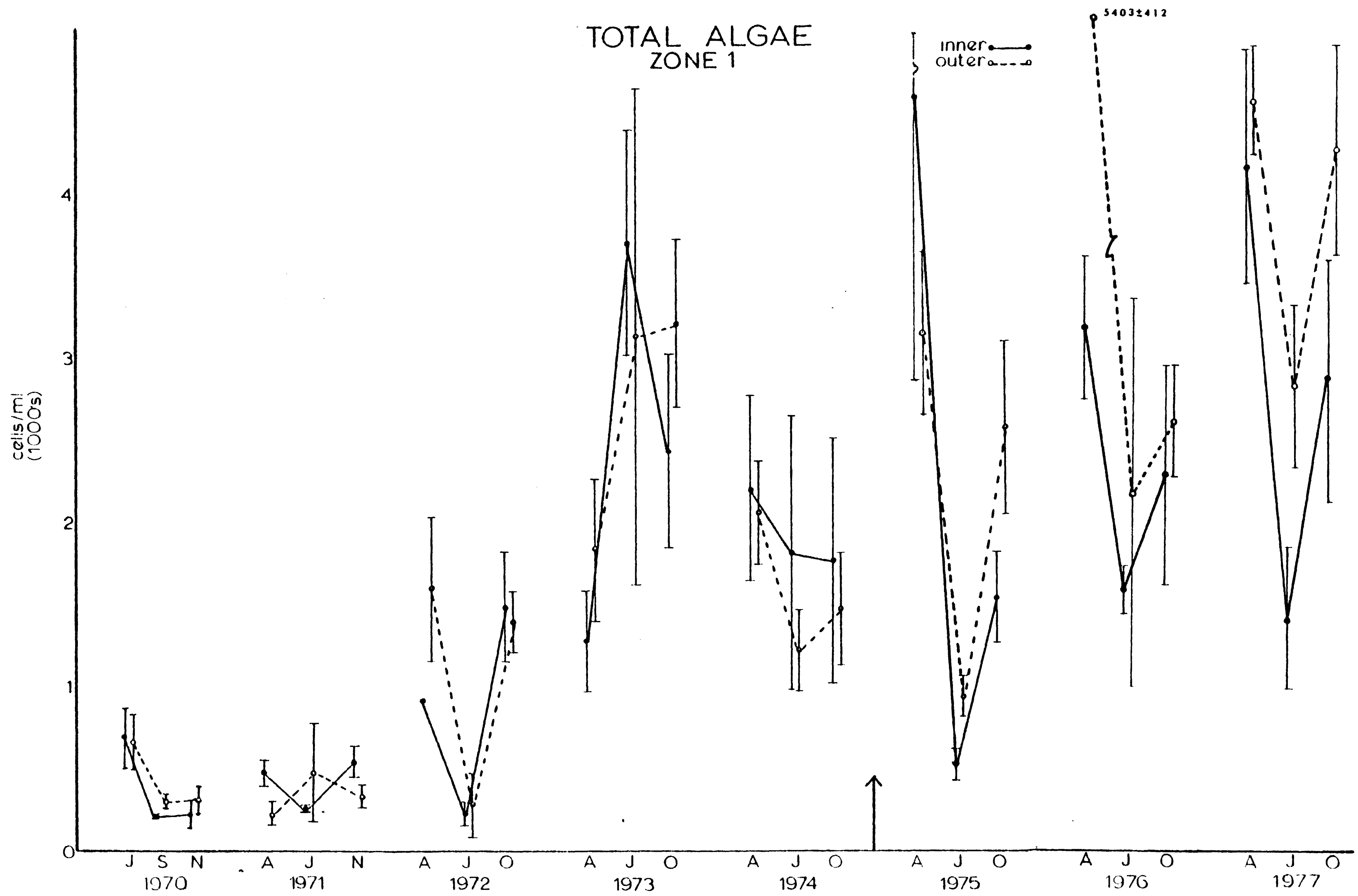

FIG. 8M. Mean abundances of total algae in Zone 1 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

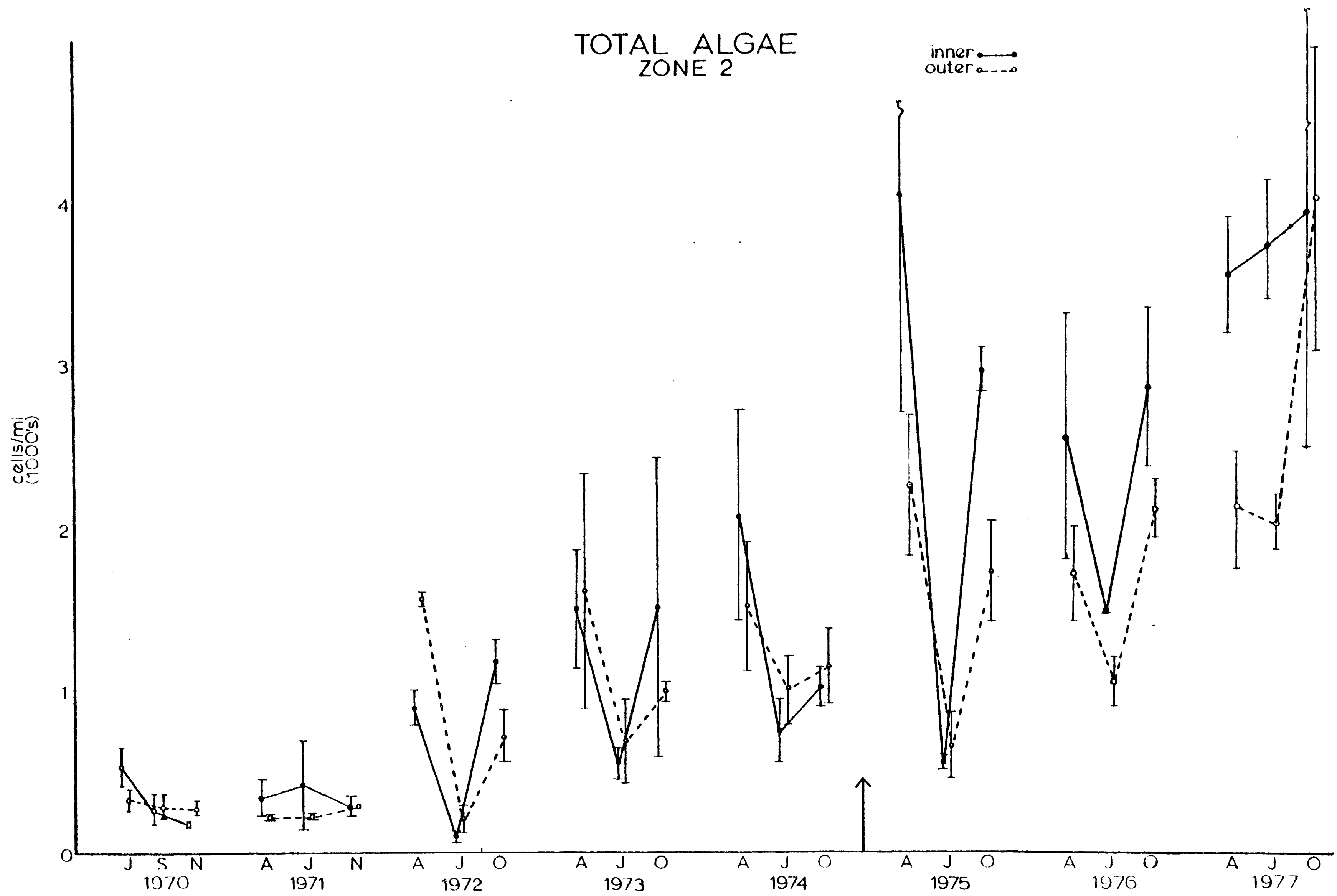

FIG. 8N. Mean abundances of total algae in Zone 2 in the spring, summer, and fall seasonal surveys of 1970 through 1977. The vertical bars show the standard errors. See Table 7 for numbers of observations.

line from 1971 through 1972 to 1974. Trends of abundance increase in the flagellates, pennate diatoms, and blue-green algae have been commented upon; it appears that these algal categories are probably responsible for the trends in total algae.

In depth Zone 0, parallelism between the annual curves of total algae abundance has been generally excellent and it is necessary to go back to 1970 and 1972 to find surveys wherein the standard errors of the means for inner and outer station groups do not overlap. Parallelism between the curves for inner and outer stations has been if anything, better in the operational years than during preoperation. The increasing abundances in both station groups must be attributed to changes in the lake, not to Cook Plant operation.

In Zone 1, parallelism between the annual curves of abundances has been better in the operational years than it was in preoperational years. Except for April 1975, abundances in this zone have been consistently higher in the outer station group. If plant operation results in heat stimulation of phytoplankton reproduction, as has been postulated, and with the plant's waste heat plume in the inner stations of Zone 1 most or all of the time, the higher abundances should have been at these stations; in eight of the nine operational surveys, however, the highest abundances were in the stations of the outer group. If plant operation results in phytoplankton inhibition at the inner stations of Zone 1, then inhibition should have been less (abundances higher) at these stations during 1975 when the plant was in the testing and power ascension phase than during 1976 and 1977 when the plant operated at higher levels and more consistently than in 1975; abundances at the inner stations, however, have continued to increase from 1975 through 1977. With the trends toward increasing abundances beginning at least as early as preoperational 1974, there is no clear evidence that operation of the plant has affected the

phytoplankton of Zone 1.

In Zone 2, parallelism between the curves of abundances at inner and outer stations has been, with the exception of July 1977, generally good since 1972. Except for July 1975 and October 1977, abundances of total algae have been greater at the inner stations in the operational-year surveys. With the plant's waste heat plume in Zone 1 most or all of the time, it would be unrealistic to attribute to plant heat the generally higher abundances at the inner stations of Zone 2. Abundances of total algae in both inner and outer stations of this offshore zone have been increasing quite consistently since 1971. Beginning during preoperation and continuing into the operational years, the increasing abundances reflect some change in the lake itself, rather than effects of plant operation.

In the time sequences of total phytoplankton abundances there is no convincing evidence that Cook Plant operation has affected the local community; the changes observed appear to be expressions of the lake's continuing eutrophication.

Inner-Outer Statistical Comparisons: Phytoplankton Abundances by Algal Categories, 1970-1977

Ayers (1978) reported preliminary statistical tests on total phytoplankton abundances (densities in cells per ml) at inner and outer station groups of shallow Zone 0 and deep Zone 2 in the years 1970 through 1976. The test used was the 2-sample Students *t* test. This section expands those preliminary statistical tests to include all ten categories of algae, the intermediate depth zone (Zone 1), and all three zones in the year 1977.

The strategy was that if plant-caused effects on the phytoplankton were present they could be expected to show consistent significant differences in

cell densities between the inner and outer stations. Corollary to this was the possibility that plant operation might differently affect phytoplankters in the three depth zones and show consistent significant differences in the affected zone but not in the others. Another corollary was that plant operation might selectively act upon only one or a few of the ten categories of algae, producing consistent significant differences in densities of the affected categories between inner and outer station groups.

For these tests spring was defined as March, April, and May; summer as June, July, and August; and fall as September, October, and November. For each season in each depth zone all available abundances of each algal category were averaged to give seasonal mean abundances at the inner and outer stations of each depth zone and comparisons were made between inner and outer mean abundances of each category in each depth zone. It was considered that lake-caused abundance changes would similarly affect both the inner and outer station groups of each depth zone in each season of each year.

Table 8 gives for each algal category in each year, season, and station group the means, variance, number of observations, and T-test of significance in each depth zone.

In Table 8 there are 591 paired comparisons of mean algal densities of which 350 are from preoperational years and 241 from the operational years 1975-77. In the eight years covered there were a total of 36 cases of significant differences of mean densities between inner and outer station groups; these amount to 6.0% of the possible comparisons.

The following tabulation gives the distribution of the cases wherein there were significant (at the .05 or .01 levels) differences between mean densities of phytoplankton categories in inner and outer station groups. In each case the order of the abbreviations is: year, depth zone, season (Sp,

Su, Fa), and I or O indicating which station group had the greater mean density of cells. Cases in operational years are underlined.

Coccoid blue-greens	75,Z2,Fa,I			
Filamentous blue-greens	75,Z1,Su,O	75,Z2,Fa,I	76,Z2,Su,I	77,Z2,Su,I
Coccoid greens	70,Z2,Su,I	71,Z2,Su,I	76,Z2,Fa,I	77,Z2,Su,I
Filamentous greens		None		
Flagellates	71,Z1,Su,O 76,Z2,Fa,I	72,Z2,Sp,O 77,Z1,Su,O	73,Z1,Fa,O 77,Z1,Fa,O	74,Z2,Fa,O
Centric diatoms	72,Z1,Sp,O	72,Z2,Fa,I	75,Z1,Fa,I	75,Z2,Fa,I
Pennate diatoms	70,Z1,Su,O	71,Z2,Su,O	73,Z1,Sp,O	75,Z2,Fa,I
Desmids	71,Z1,Su,O	71,Z2,Su,I		
Other algae	71,Z1,Sp,O 74,Z2,Sp,I	73,Z0,Sp,I 77,Z2,Fa,I	73,Z1,Sp,I	73,Z2,Fa,I
Total algae	72,Z0,Sp,O	72,Z2,Sp,O	76,Z1,Sp,O	77,Z2,Su,I

Summarized by years the cases of significant difference were:

1970 (2 seasons)	2 cases	1974	2 cases
1971	6	1975	6
1972	5	1976	4
1973	5	1977	6

It is noted that the six cases of difference in operational 1975 and 1977 are not greater than the six that occurred in preoperational 1971; it is also noted that the four in operational 1976 are less than the five that occurred in preoperational 1972 and 1973. The numbers of cases by years appears to be within the natural range of variation, and no effect of plant operation is evident.

Summarized by depth zones, with the station group having the greatest density of algae indicated and with operational year cases underlined, the cases of significant difference were:

TABLE 8. Algal densities (cells/ml) at inner (treatment) and outer (control) station groups in three depth zones by years and field seasons since summer 1970. In each season in each zone the mean count of cells/ml at inner stations is compared to that at outer stations using a two-sample t-test. Symbols used: n.s. = no significant difference between the two groups; * = significance at the .05 level; ** = significance at the .01 level; N = the number of stations for which data were available in that season. No test was made if one of the groups contained only a single observation or if one of the group variances was zero.

COCCOID BLUE-GREEN ALGAE.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1970													
Summer	Inner	15.909	2233.7	11	0.8540 n.s.	229.67	158240	3	----	0	0	2	----
	Outer	20.100	3099.2	10		0	0	4		0	0	4	
Fall	Inner	7.4500	34.787	20	0.3500 n.s.	6.5000	15.100	6	0.1759 n.s.	10.500	65.667	4	0.4877 n.s.
	Outer	9.4500	54.576	20		12.000	75.143	8		13.750	49.357	8	
1971													
Spring	Inner	1.6000	5.3778	10	0.1336 n.s.	1.3333	2.3333	3	0.5185 n.s.	.50000	.50000	2	1.0000 n.s.
	Outer	.25000	.50000	8		.66667	.33333	3		.50000	.33333	4	
Summer	Inner	.20000	.40000	10	0.3286 n.s.	0	0	3	----	0	0	2	----
	Outer	3.5000	107.61	10		0	0	3		.50000	.33333	4	
Fall	Inner	45.000	478.40	6	0.2368 n.s.	64.000	288.00	2	0.1726 n.s.	43.000	32.000	2	----
	Outer	59.330	299.87	6		36.500	60.500	2		41.000	----	1	
1972													
Spring	Inner	1.2857	6.5714	7	0.4939 n.s.	0	----	1	----	.50000	.50000	2	----
	Outer	2.5000	9.0000	4		1.0000	0	2		0	0	2	
Summer	Inner	.37500	.55357	8	0.3505 n.s.	0	0	3	----	0	0	2	----
	Outer	.11111	.11111	9		0	0	4		0	0	4	
Fall	Inner	46.375	849.70	8	0.2146 n.s.	104.00	2196.0	3	1.0000 n.s.	143.50	1104.5	2	0.6158 n.s.
	Outer	67.600	1470.0	10		104.00	1928.7	4		234.00	48975	4	
1973													
Spring	Inner	4.2500	58.786	8	----	0	0	3	----	8.5000	144.50	2	0.3079 n.s.
	Outer	0	0	8		3.5000	33.000	4		.66667	1.3333	3	
Summer	Inner	29.429	1168.6	7	0.9020 n.s.	47.667	1754.3	3	0.7547 n.s.	11.500	40.500	2	0.4179 n.s.
	Outer	27.444	849.28	9		39.500	579.67	4		140.50	36322	4	
Fall	Inner	21.000	182.67	7	0.1024 n.s.	40.333	65.333	3	0.0709 n.s.	30.000	98.000	2	0.9729 n.s.
	Outer	32.714	124.57	7		27.750	42.917	4		30.000	52.250	4	
1974													
Spring	Inner	.66667	2.0000	9	0.1471 n.s.	.16667	.16667	3	----	0	0	2	----
	Outer	49.100	9092.5	10		0	----	1		0	0	4	
Summer	Inner	23.636	1634.7	11	0.3615 n.s.	52.333	8216.3	3	0.3934 n.s.	0	0	2	----
	Outer	59.333	14147	9		109.00	5051.3	4		49.500	531.67	4	
Fall	Inner	692.67	285130	12	0.1485 n.s.	790.33	516120	3	0.5692 n.s.	538.50	9940.5	2	0.9627 n.s.
	Outer	385.90	156580	10		544.50	121590	4		523.00	169560	4	
1975													
Spring	Inner	114.08	27288	12	0.9713 n.s.	37.000	4107.0	3	0.4163 n.s.	202.50	82013	2	0.1924 n.s.
	Outer	110.30	97781	10		8.2500	272.25	4		7.5000	225.0	4	
Summer	Inner	15.250	475.66	12	0.5025 n.s.	38.333	2961.3	3	0.4058 n.s.	13.500	40.50	2	0.4564 n.s.
	Outer	22.778	827.19	9		13.250	208.92	4		24.000	275.33	4	
Fall	Inner	730.58	362580	12	0.9931 n.s.	536.33	5212.3	3	0.3335 n.s.	1399.5	75661	2	0.0364 *
	Outer	728.50	234880	10		908.50	342200	4		776.50	46839	4	

TABLE 8 continued.

COCCOID BLUE-GREEN ALGAE cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1976													
Spring	Inner	124.63	34909	12	0.8351 n.s.	4.4333	58.963	3	0.2301 n.s.	58.050	6739.6	2	0.8782 n.s.
	Outer	146.57	88513	10		528.92	421130	4		76.700	20929	4	
Summer	Inner	100.52	24395	12	0.6886 n.s.	48.100	2346.0	3	0.6733 n.s.	4.9300	49.005	2	0.2839 n.s.
	Outer	74.620	19347	10		66.125	3073.8	4		102.17	10974	4	
Fall	Inner	219.69	58153	12	0.2690 n.s.	416.73	319920	3	0.5649 n.s.	272.75	148790	2	0.9702 n.s.
	Outer	393.13	211030	10		241.25	18703	4		260.33	94136	3	
1977													
Spring	Inner	24.875	7425.2	12	0.4638 n.s.	332.70	191340	3	0.3527 n.s.	182.40	66540	2	0.1963 n.s.
	Outer	53.050	8172.5	10		92.850	29099	4		8.3000	275.56	4	
Summer	Inner	262.38	142330	12	0.7937 n.s.	59.700	9263.4	3	0.5441 n.s.	281.85	35192	2	0.1676 n.s.
	Outer	299.54	44176	9		105.62	8069.8	4		86.000	12332	4	
Fall	Inner	2127.0	5615200	12	0.2480 n.s.	1375.1	1285200	3	0.3913 n.s.	2468.8	2922200	2	0.8192 n.s.
	Outer	1104.4	2088800	10		2295.6	1894300	4		2805.0	2397900	4	
FILAMENTOUS BLUE-GREEN ALGAE													
1970													
Summer	Inner	37.091	186.69	12	0.5163 n.s.	24.667	100.33	3	0.2935 n.s.	36.500	1512.5	2	0.8398 n.s.
	Outer	32.400	348.71	10		44.750	770.25	4		31.000	652.00	4	
Fall	Inner	1.6000	2.3579	20	0.8780 n.s.	1.5000	1.5000	6	0.4773 n.s.	4.2500	16.250	4	0.1492 n.s.
	Outer	1.7000	6.0105	20		2.2500	5.0714	8		1.7500	2.7857	8	
1971													
Spring	Inner	13.700	280.90	10	0.5925 n.s.	6.6667	4.3333	3	0.3465 n.s.	5.5000	4.5000	2	0.7396 n.s.
	Outer	10.250	44.214	8		5.0000	3.0000	3		5.0000	2.0000	4	
Summer	Inner	8.6000	20.711	10	0.2338 n.s.	10.000	21.000	3	0.6972 n.s.	13.000	98.000	2	0.1443 n.s.
	Outer	11.400	30.933	10		12.333	72.333	3		5.0000	2.0000	4	
Fall	Inner	1.8333	2.9667	6	0.6748 n.s.	2.5000	4.5000	2	----	1.5000	.50000	2	----
	Outer	2.3333	5.0667	6		0	0	2		2.0000	----	1	
1972													
Spring	Inner	2.7143	23.905	7	0.1116 n.s.	0	----	1	----	5.0000	0	2	----
	Outer	11.000	120.67	4		9.0000	18.000	2		6.0000	32.000	2	
Summer	Inner	71.250	5258.2	8	0.1650 n.s.	18.667	60.333	3	0.4838 n.s.	4.5000	4.5000	2	0.5536 n.s.
	Outer	31.889	1174.1	9		26.000	228.67	4		24.750	1749.9	4	
Fall	Inner	13.625	143.13	8	0.2906 n.s.	2.3333	10.333	3	0.4333 n.s.	2.5000	.50000	2	0.2762 n.s.
	Outer	29.700	1598.0	10		4.2500	7.5833	4		1.2500	1.5833	4	
1973													
Spring	Inner	4.0000	24.571	8	0.8907 n.s.	8.6667	58.333	3	0.3461 n.s.	8.0000	2.0000	2	0.3356 n.s.
	Outer	4.3750	52.839	8		4.0000	18.667	4		4.0000	21.000	3	
Summer	Inner	27.143	1852.1	7	0.2835 n.s.	10.333	108.33	3	0.9827 n.s.	3.0000	2.0000	2	0.3037 n.s.
	Outer	11.111	34.611	9		10.500	80.333	4		6.5000	15.000	4	
Fall	Inner	13.143	121.87	7	0.7732 n.s.	11.667	30.333	3	0.1711 n.s.	11.500	144.50	2	0.3042 n.s.
	Outer	11.429	114.95	7		6.5000	9.6667	4		5.0000	6.0000	4	

TABLE 8 continued.

FILAMENTOUS BLUE-GREEN ALGAE cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1974													
Spring	Inner	30.111	559.86	9	0.9692 n.s.	23.500	39.500	3	----	21.500	40.500	2	0.3058 n.s.
	Outer	29.700	488.01	10		11.000	----	1		11.500	115.67	4	
Summer	Inner	14.364	464.25	11	0.8765 n.s.	26.333	464.33	3	0.4636 n.s.	4.0000	8.0000	2	0.0911 n.s.
	Outer	13.000	253.75	9		106.25	28686	4		30.250	246.92	4	
Fall	Inner	6.4167	152.81	12	0.9709 n.s.	.66667	1.3333	3	0.6729 n.s.	1.0000	2.0000	2	0.5686 n.s.
	Outer	6.2000	229.29	10		1.5000	9.0000	4		14.500	841.00	4	
1975													
Spring	Inner	10.142	125.22	12	0.3304 n.s.	25.000	657.00	3	0.4723 n.s.	11.000	32.000	2	0.0798 n.s.
	Outer	6.0700	48.916	10		12.750	272.25	4		3.2500	8.9167	4	
Summer	Inner	147.17	19352	12	0.6316 n.s.	46.333	800.33	3	0.0116 *	70.500	840.50	2	0.6629 n.s.
	Outer	173.89	10114	9		245.00	6946.0	4		120.50	19847	4	
Fall	Inner	73.667	9165.5	12	0.1568 n.s.	46.333	1234.3	3	0.1467 n.s.	169.00	882.00	2	0.0123 *
	Outer	28.300	323.79	10		156.25	10890	4		36.000	1382.0	4	
1976													
Spring	Inner	82.075	2561.7	12	0.6122 n.s.	60.233	428.70	3	0.1299 n.s.	21.550	271.44	2	0.7665 n.s.
	Outer	94.180	3566.3	10		98.650	999.51	4		18.250	101.15	4	
Summer	Inner	70.400	6315.1	12	0.6558 n.s.	386.87	2444.3	3	0.5311 n.s.	397.90	7938.0	2	0.0023 **
	Outer	87.460	9511.2	10		1300.3	5254800	4		53.650	1762.6	4	
Fall	Inner	60.242	7885.7	12	0.0658 n.s.	1.1000	3.6300	3	0.4187 n.s.	15.750	496.13	2	0.8501 n.s.
	Outer	5.1500	72.643	10		12.850	505.82	4		22.100	1465.2	3	
1977													
Spring	Inner	37.442	193.16	12	0.3830 n.s.	51.400	1741.2	3	0.3900 n.s.	35.650	609.00	2	0.4076 n.s.
	Outer	31.330	332.90	10		31.480	120.78	4		19.480	341.29	4	
Summer	Inner	240.30	58717	12	0.9546 n.s.	77.930	2616.7	3	0.2299 n.s.	1575.1	314030	2	0.0043 **
	Outer	231.77	186750	9		759.17	707930	4		97.630	9965.5	4	
Fall	Inner	28.730	1044.8	12	0.3512 n.s.	11.530	35.250	3	0.2814 n.s.	4.9500	5.4450	2	0.3544 n.s.
	Outer	52.89	6485.5	10		23.200	243.38	4		13.250	110.00	4	
COCCOID GREEN ALGAE													
1970													
Summer	Inner	111.91	9342.5	11	0.1394 n.s.	41.000	1461.0	3	0.3372 n.s.	201.00	11858	2	0.0286 *
	Outer	236.80	62106	10		85.250	3994.9	4		31.500	598.33	4	
Fall	Inner	23.750	462.30	20	0.9947 n.s.	44.500	1247.5	6	0.7625 n.s.	33.000	1198.0	4	0.9660 n.s.
	Outer	23.800	670.91	20		38.750	1142.8	8		33.625	266.84	8	
1971													
Spring	Inner	25.100	741.21	10	0.8341 n.s.	6.0000	3.0000	3	0.2051 n.s.	5.5000	40.500	2	0.9000 n.s.
	Outer	27.750	621.07	8		3.3333	6.3333	3		5.0000	11.333	4	
Summer	Inner	160.10	8753.0	10	0.2883 n.s.	83.667	3170.3	3	0.4051 n.s.	183.00	15488	2	0.0299 *
	Outer	267.50	87596	10		370.33	281960	3		5.0000	11.333	4	
Fall	Inner	69.167	1588.6	6	0.9150 n.s.	116.00	1800.0	2	0.2181 n.s.	59.500	1104.5	2	----
	Outer	71.333	763.87	6		58.000	338.00	2		38.000	----	1	

TABLE 8 continued.

COCCOID GREEN ALGAE cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1972													
Spring	Inner	273.29	59198	7	0.1116 n.s.	135.00	----	1	----	89.500	1740.5	2	0.6946 n.s.
	Outer	541.50	58222	4		131.50	544.50	2		111.50	2964.5	2	
Summer	Inner	73.750	4940.5	8	0.4612 n.s.	33.330	2160.3	3	0.5860 n.s.	32.500	1404.5	2	0.4335 n.s.
	Outer	62.440	9284.3	9		107.00	48383	4		14.750	272.25	4	
Fall	Inner	103.00	1061.7	8	0.3097 n.s.	67.000	43.000	3	0.3880 n.s.	59.000	1922.0	2	0.3608 n.s.
	Outer	139.20	8580.6	10		55.250	412.92	4		37.000	168.67	4	
1973													
Spring	Inner	93.875	8587.0	8	0.2271 n.s.	46.000	1521.0	3	0.8392 n.s.	70.500	684.50	2	0.1230 n.s.
	Outer	48.625	1675.4	8		38.500	2502.3	4		37.000	103.00	3	
Summer	Inner	158.00	16678	7	0.4291 n.s.	266.00	105270	3	0.8076 n.s.	39.000	1352.0	2	0.3861 n.s.
	Outer	290.56	170050	9		212.50	53903	4		92.000	4834.7	4	
Fall	Inner	63.430	10104	7	0.3582 n.s.	28.000	19.000	3	0.6713 n.s.	26.000	0	2	----
	Outer	25.286	1053.6	7		24.000	212.67	4		7.5000	20.330	4	
1974													
Spring	Inner	28.440	1588.0	9	0.1340 n.s.	83.000	8593.6	3	----	208.00	46.208	2	0.1305 n.s.
	Outer	76.500	6930.7	10		17.000	----			25.000	1121.3	4	
Summer	Inner	14.000	301.20	11	0.0689 n.s.	66.670	3562.3	3	0.6604 n.s.	81.000	8712.0	2	0.5830 n.s.
	Outer	47.110	2886.1	9		48.750	1836.3	4		49.000	2214.7	4	
Fall	Inner	74.330	2745.9	12	0.9244 n.s.	30.670	322.33	3	0.1992 n.s.	0	0	2	----
	Outer	71.100	10355	10		121.00	10443			42.500	332.33	4	
1975													
Spring	Inner	53.750	2631.1	12	0.0753 n.s.	137.67	22484	3	0.2804 n.s.	26.500	1404.5	2	0.3822 n.s.
	Outer	21.130	447.99	10		47.000	1052.7	4		9.7500	50.250	4	
Summer	Inner	301.83	18973	12	0.3135 n.s.	215.33	5554.3	3	0.3222 n.s.	218.50	544.50	2	0.9215 n.s.
	Outer	366.00	20828	9		317.50	21027	4		231.25	26046	4	
Fall	Inner	67.083	624.99	12	0.0193 *	52.330	1001.3	3	0.2192 n.s.	56.000	242.00	2	0.4396 n.s.
	Outer	120.50	4577.6	10		83.000	694.07	4		78.750	1170.9	4	
1976													
Spring	Inner	148.40	17347	12	0.2231 n.s.	68.530	3767.2	3	0.2766 n.s.	35.650	999.04	2	0.4536 n.s.
	Outer	90.340	4640.9	10		111.50	1027.5	4		23.625	40.762	4	
Summer	Inner	526.17	81721	12	0.4206 n.s.	296.23	6770.7	3	0.3108 n.s.	150.05	999.04	2	0.4795 n.s.
	Outer	422.14	94098	10		234.40	4083.8	4		237.72	22191	4	
Fall	Inner	377.36	88784	12	0.4324 n.s.	175.77	7000.1	3	0.6552 n.s.	227.15	1235.0	2	0.0188 *
	Outer	286.35	47846	10		148.40	4842.6	4		117.17	392.41	3	
1977													
Spring	Inner	97.970	6592.0	12	0.8450 n.s.	66.330	1234.2	3	0.6046 n.s.	76.250	928.80	2	0.1295 n.s.
	Outer	90.370	9782.3	10		50.980	1387.9	4		34.400	548.51	4	
Summer	Inner	266.39	22645	12	0.3886 n.s.	97.270	6161.0	3	0.2178 n.s.	392.95	14878	2	0.0297 *
	Outer	209.64	19390	9		212.00	14833	4		154.62	4263.2	4	
Fall	Inner	252.15	17209	12	0.6336 n.s.	70.730	748.26	3	0.0890 n.s.	98.650	3034.2	2	0.6503 n.s.
	Outer	223.82	20481	10		172.85	6215.0	4		71.730	4372.3	4	

TABLE 8 continued.

FILAMENTOUS GREEN ALGAE

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1970													
Summer	Inner	2.2727	6.6182	11	0.3581 n.s.	4.6667	25.330	3	0.3326 n.s.	3.0000	18.000	2	0.4445 n.s.
	Outer	3.4000	8.4889	10		1.7500	4.2500	4		1.2500	1.5830	4	
Fall	Inner	0.8000	1.0105	20	0.1820 n.s.	1.0000	1.2000	6	0.6910 n.s.	1.5000	5.6667	4	0.6021 n.s.
	Outer	1.3000	1.6947	20		1.2500	1.3571	8		1.0000	.85714	8	
1971													
Spring	Inner	1.5000	5.7667	10	0.7552 n.s.	2.0000	12.000	3	----	0	0	2	----
	Outer	1.8750	7.5536	8		0	0	3		0	0		
Summer	Inner	5.5000	8.7220	10	0.1868 n.s.	4.0000	9.0000	3	0.2589 n.s.	3.5000	24.500	2	----
	Outer	8.3000	32.900	10		76667	14.330	3		0	0	4	
Fall	Inner	.66667	1.0667	6	0.5995 n.s.	1.5000	.50000	2	0.2929 n.s.	.50000	.50000	2	----
	Outer	1.0000	1.2000	6		.50000	.50000	2		0	----	1	
1972													
Spring	Inner	1.0000	2.3300	7	0.1547 n.s.	2.0000	----	1	----	3.5000	4.5000	2	0.5918 n.s.
	Outer	7.5000	129.00	4		1.5000	.50000	2		2.5000	2.5000	2	
Summer	Inner	3.2500	10.214	8	0.0584 n.s.	2.0000	4.0000	3	1.0000 n.s.	.50000	.50000	2	----
	Outer	.89000	1.6100	9		2.0000	4.6667	4		0	0	4	
Fall	Inner	.50000	2.0000	8	0.5260 n.s.	.67000	.33333	3	0.9001 n.s.	0	0	2	----
	Outer	1.1000	5.2110	10		.75000	.91667	4		.50000	1.0000	4	
1973													
Spring	Inner	1.7500	9.9286	8	0.6265 n.s.	2.0000	12.000	3	0.6888 n.s.	1.0000	2.0000	2	0.7888 n.s.
	Outer	1.1250	2.6964	8		1.2500	.91664	4		.66667	1.3333	3	
Summer	Inner	1.4286	3.9524	7	0.4221 n.s.	2.3333	6.3300	3	0.7081 n.s.	0	0	2	----
	Outer	3.2200	29.440	9		3.7500	32.230	4		0	0		
Fall	Inner	.57000	2.2900	7	0.8448 n.s.	0	0	3	----	.50000	.50000	2	0.8407 n.s.
	Outer	.43000	1.2900	7		.25000	2.2500	4		.75000	2.2500	4	
1974													
Spring	Inner	3.6700	24.250	9	0.5653 n.s.	2.3300	18.670	3	----	3.0000	2.0000	2	0.2846 n.s.
	Outer	6.7000	217.79	10		0	----	1		1.0000	4.0000	4	
Summer	Inner	14.909	284.89	11	0.3829 n.s.	76.330	4446.3	3	0.1355 n.s.	6.5000	40.500	2	0.2903 n.s.
	Outer	22.110	366.11	9		16.500	269.67	4		33.750	876.92	4	
Fall	Inner	3.7500	44.210	12	0.7419 n.s.	0	0	3	----	0	0	2	----
	Outer	5.3000	207.12	10		0	0	4		0	0	4	
1975													
Spring	Inner	.33333	.42424	12	0.7339 n.s.	9.3300	16.330	3	----	2.0000	8.0000	2	----
	Outer	.47000	1.4868	10		0	0			4.0000	0	4	
Summer	Inner	.25000	.75000	12	0.6549 n.s.	0	0	3	----	0	0	2	----
	Outer	.11000	.11000	9		0	0	4		0	0	4	
Fall	Inner	1.0000	3.4500	12	0.1962 n.s.	0	0	3	----	3.5000	.50000	2	----
	Outer	6.7000	216.01	10		2.5000	5.6700	4		0	0	4	
1976													
Spring	Inner	173.47	34224	12	0.0852 n.s.	64.100	5556.7	3	0.9492 n.s.	76.250	11628	2	0.7508 n.s.
	Outer	55.880	9276.4	10		58.850	13853	4		134.30	47863	4	

TABLE 8 continued.

FILAMENTOUS GREEN ALGAE cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1976													
Summer	Inner	4.0800	21.640	12	0.4234 n.s.	0	0	3	----	1.6500	5.4500	2	----
	Outer	2.4900	19.140	10		1.0250	4.2030	4		0	0	4	
Fall	Inner	25.290	578.36	12	0.5553 n.s	11.600	183.73	3	0.3935 n.s.	4.1500	34.445	2	0.8027 n.s.
	Outer	20.060	214.78	10		4.5750	39.389	4		6.6300	132.00	3	
1977													
Spring	Inner	0.9670	5.2130	12	0.5920 n.s.	0	0	3	----	0	0	2	----
	Outer	1.6500	12.710	10		7.8750	94.170	4		3.3250	44.220	4	
Summer	Inner	5.6700	23.220	12	0.2834 n.s.	0.2700	.21000	3	0.0905 n.s.	3.3500	5.4500	2	0.5811 n.s.
	Outer	8.8600	69.980	9		2.9000	4.3800	4		2.0800	6.2200	4	
Fall	Inner	8.5700	243.26	12	0.1287 n.s.	0	0	3	----	0	0	2	----
	Outer	0.6600	4.3600	10		1.6500	10.890	4		0	0	4	
FLAGELLATES													
1970													
Summer	Inner	184.73	22917	11	0.6995 n.s.	257.33	83625	3	0.4764 n.s.	84.000	9800.0	2	0.9919 n.s.
	Outer	105.10	2280.3	10		145.25	4872.9	4		84.500	557.67	4	
Fall	Inner	157.30	8951.8	20	0.5916 n.s.	131.17	8003.4	6	0.2697 n.s.	131.00	1552.7	4	0.5655 n.s.
	Outer	177.20	18101	20		197.00	13303	8		151.00	3647.7	8	
1971													
Spring	Inner	259.20	16972	10	0.7278 n.s.	155.67	1925.3	3	0.0525 n.s.	144.00	9522.0	2	0.2758 n.s.
	Outer	284.00	27961	8		61.667	1633.3	3		82.500	1053.7	4	
Summer	Inner	62.700	1558.0	10	0.0464 *	44.330	81.330	3	0.2137 n.s.	104.50	5512.5	2	0.6144 n.s.
	Outer	75.000	1308.8	10		66.670	604.33	3		82.500	1053.7	4	
Fall	Inner	114.50	1832.3	6	0.4568 n.s.	176.00	162.00	2	0.9073 n.s.	120.00	4232.0	2	----
	Outer	139.17	4259.8	6		172.00	1682.0	2		162.00	----	1	
1972													
Spring	Inner	449.43	128850	7	0.3081 n.s.	301.00	----	1	----	246.00	200.00	2	0.0257 *
	Outer	669.00	57745	4		464.00	18432	2		428.00	1568.0	2	
Summer	Inner	188.25	45582	8	0.2919 n.s.	39.670	449.33	3	0.5845 n.s.	28.500	480.50	2	0.2472 n.s.
	Outer	98.667	13520	9		56.750	2144.9	4		90.750	3598.3	4	
Fall	Inner	223.13	38444	8	0.3519 n.s.	297.33	8190.3	3	0.8727 n.s.	226.00	450.00	2	0.9067 n.s.
	Outer	303.00	24925	10		312.75	18424	4		236.00	11274	4	
1973													
Spring	Inner	257.38	15283	8	0.8189 n.s.	332.67	35833	3	0.9771 n.s.	287.50	3280.5	2	0.6021 n.s.
	Outer	241.75	20583	8		328.50	30475	4		254.67	4112.3	3	
Summer	Inner	182.43	16124	7	0.5224 n.s.	250.67	18772	3	0.9636 n.s.	94.500	9940.5	2	0.7264 n.s.
	Outer	145.11	10202	9		257.50	45530	4		76.750	658.92	4	
Fall	Inner	325.86	29503	7	0.0143 *	528.33	51090	3	0.3398 n.s.	348.00	27378	2	0.4470 n.s.
	Outer	750.29	124620	7		865.75	258260	4		477.75	33053	4	
1974													
Spring	Inner	278.22	82276	9	0.9049 n.s.	367.00	92772	6	----	495.50	60901	2	0.1782 n.s.
	Outer	294.10	80179	10		339.00	----	1		219.75	30515	4	

TABLE 8 continued.

FLAGELLATES cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1974													
Summer	Inner	282.55	41183	11	0.1349 n.s.	369.67	83733	3	0.6839 n.s.	190.00	6498.0	2	0.3355 n.s.
	Outer	487.56	139556	9		301.50	15415	4		290.75	12920	4	
Fall	Inner	316.75	25515	12	0.2981 n.s.	369.67	105250	3	0.9473 n.s.	174.50	364.50	2	0.0338 *
	Outer	612.50	955060	10		356.75	28467	4		257.75	1104.3	4	
1975													
Spring	Inner	525.58	128800	12	0.4125 n.s.	904.67	636600	3	0.4352 n.s.	403.50	2964.5	2	0.9387 n.s.
	Outer	389.70	162090	10		584.25	150660	4		415.25	35643	4	
Summer	Inner	379.75	167520	12	0.6130 n.s.	129.00	2667.0	3	0.1936 n.s.	151.50	1404.5	2	0.8089 n.s.
	Outer	302.89	42455	9		224.75	9844.9	4		192.25	43782	4	
Fall	Inner	472.67	14020	12	0.7776 n.s.	537.33	39260	3	0.2230 n.s.	811.50	8580.5	2	0.3368 n.s.
	Outer	457.20	18240	10		823.50	94807	4		564.75	88168	4	
1976													
Spring	Inner	1051.3	312300	12	0.8402 n.s.	872.67	56953	3	0.0687 n.s.	737.00	22176	2	0.5034 n.s.
	Outer	1104.3	435050	10		1524.6	189180	4		549.20	108860	4	
Summer	Inner	637.65	116040	12	0.2947 n.s.	504.90	26752	3	0.4969 n.s.	700.55	1878.8	2	0.2250 n.s.
	Outer	509.93	28896	10		390.87	51440	4		439.77	58196	4	
Fall	Inner	481.65	52349	12	0.5585 n.s.	563.73	121970	3	0.3226 n.s.	991.50	6361.9	2	0.0055 **
	Outer	535.23	34287	10		808.82	61265	4		584.67	2545.5	3	
1977													
Spring	Inner	2267.1	544210	12	0.2446 n.s.	1629.3	207050	3	0.1813 n.s.	1486.6	1496.0	2	0.1275 n.s.
	Outer	1891.4	525470	10		2319.2	426380	4		1017.6	105640	4	
Summer	Inner	609.75	74159	12	0.6433 n.s.	160.53	3970.6	3	0.0279 *	474.20	21136	2	0.6721 n.s.
	Outer	550.94	88806	9		538.87	40842	4		536.97	26659	4	
Fall	Inner	806.52	436790	12	0.8887 n.s.	632.27	5913.7	3	0.0264 *	701.40	1984.5	2	0.7232 n.s.
	Outer	770.48	250070	10		773.05	1891.4	4		631.62	59269	4	
CENTRIC DIATOMS													
1970													
Summer	Inner	330.45	140550	11	0.5136 n.s.	5.3300	6.3300	3	0.3941 n.s.	6.0000	8.0000	2	0.5328 n.s.
	Outer	444.90	170670	10		106.75	33817	4		12.750	171.58	4	
Fall	Inner	41.800	3182.1	20	0.2186 n.s.	5.5000	32.700	6	0.3556 n.s.	10.500	101.67	4	0.4490 n.s.
	Outer	80.800	16254	20		15.625	629.41	8		17.000	215.71	8	
1971													
Spring	Inner	361.60	57032	10	0.5909 n.s.	140.33	484.33	3	0.1880 n.s.	122.00	3362.0	2	0.1901 n.s.
	Outer	424.38	59746	8		92.330	2265.3	3		73.750	544.92	4	
Summer	Inner	27.300	266.68	10	0.7279 n.s.	12.667	42.330	3	0.3175 n.s.	22.000	722.00	2	0.0696 n.s.
	Outer	30.900	771.43	10		40.330	1721.3	3		73.750	544.92	4	
Fall	Inner	8.0000	30.400	6	0.9254 n.s.	9.0000	72.000	2	0.6115 n.s.	5.5000	.50000	2	----
	Outer	8.3300	41.870	6		5.0000	18.000	2		4.0000	----	1	
1972													
Spring	Inner	741.57	631400	7	0.0447 *	90.000	----	1	----	99.500	760.50	2	0.1414 n.s.
	Outer	1784.5	265920	4		302.00	4050.0	2		316.50	16021	2	

TABLE 8 continued.

CENTRIC DIATOMS cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1972													
Summer	Inner	24.875	912.13	8	0.4046 n.s.	9.0000	7.0000	3	0.7042 n.s.	8.0000	2.0000	2	0.5220 n.s.
	Outer	15.440	162.03	9		7.0000	66.000	4		15.250	189.58	4	
Fall	Inner	1561.5	852530	8	0.4925 n.s.	635.67	114460	3	0.8095 n.s.	436.50	2112.5	2	0.0004 **
	Outer	2026.9	2806000	10		578.75	66980	4		69.000	1218.7	4	
1973													
Spring	Inner	633.25	47351	8	0.1458 n.s.	717.00	56821	3	0.3736 n.s.	809.00	131070	2	0.8287 n.s.
	Outer	1003.4	414540	8		1140.8	499960	4		976.67	844210	3	
Summer	Inner	2111.0	2687300	7	0.6443 n.s.	2720.0	1297000	3	0.8757 n.s.	307.50	2244.5	2	0.9942 n.s.
	Outer	1784.3	1287100	9		2458.3	6361500	4		305.25	151670	4	
Fall	Inner	1573.1	271256	7	0.4327 n.s.	1448.7	620690	3	0.5313 n.s.	841.00	1031000	2	0.2926 n.s.
	Outer	1272.6	688480	7		1103.8	338770	4		288.00	27079	4	
1974													
Spring	Inner	740.33	141000	9	0.9594 n.s.	740.17	139170	3	----	528.50	41761	2	0.9295 n.s.
	Outer	730.60	192390	10		899.60	----	1		547.75	60449	4	
Summer	Inner	422.36	43147	11	0.7048 n.s.	265.00	80307	3	0.4997 n.s.	110.50	3784.5	2	0.3418 n.s.
	Outer	381.56	71239	9		159.75	6315.6	4		205.75	12625	4	
Fall	Inner	308.08	13564	12	0.3015 n.s.	234.00	9759.0	3	0.5867 n.s.	128.50	24.500	2	0.9508 n.s.
	Outer	404.70	83987	10		204.75	744.25	4		131.75	4346.3	4	
1975													
Spring	Inner	1747.3	615100	12	0.9844 n.s.	2096.7	1596700	3	0.3066 n.s.	2308.0	1051300	2	0.0629 n.s.
	Outer	1756.8	2050500	10		1319.3	268170	4		1041.0	86442	4	
Summer	Inner	34.000	311.45	12	0.2898 n.s.	25.330	149.33	3	0.3116 n.s.	26.500	312.5	2	0.2603 n.s.
	Outer	47.780	1527.2	9		70.750	4556.3	4		64.000	1352.0	4	
Fall	Inner	137.42	1233.4	12	0.0337 *	104.67	1769.3	3	0.2149 n.s.	153.00	2.0000	2	0.0312 *
	Outer	197.50	6906.9	10		156.50	2627.7	4		82.000	844.00	4	
1976													
Spring	Inner	2214.9	967810	12	0.2437 n.s.	926.33	62034	3	0.1573 n.s.	776.80	119660	2	0.0706 n.s.
	Outer	1756.7	580460	10		1554.4	366400	4		401.67	1847.6	4	
Summer	Inner	640.01	319670	12	0.6945 n.s.	225.50	13706	3	0.1378 n.s.	134.30	87.12	2	0.2087 n.s.
	Outer	761.65	738710	10		119.97	1072.0	4		184.87	1999.6	4	
Fall	Inner	671.24	78299	12	0.5898 n.s.	506.27	40319	3	0.8076 n.s.	683.15	1409.8	2	0.5613 n.s.
	Outer	608.36	63146	10		470.05	29950	4		551.03	73365	3	
1977													
Spring	Inner	621.08	20862	12	0.1322 n.s.	453.73	40042	3	0.9057 n.s.	393.80	397.62	2	0.4732 n.s.
	Outer	488.79	60614	10		470.90	27586	4		340.72	7871.7	4	
Summer	Inner	1056.3	206780	12	0.9402 n.s.	655.23	111810	3	0.4264 n.s.	624.30	28896	2	0.5046 n.s.
	Outer	1041.4	190480	9		858.05	82402	4		783.22	74086	4	
Fall	Inner	442.99	61246	12	0.1893 n.s.	235.97	4269.6	3	0.3034 n.s.	194.80	1003.5	2	0.8419 n.s.
	Outer	932.65	1498800	10		294.70	4649.4	4		174.82	15338	4	

TABLE 8 continued.

PENNATE DIATOMS

Year & Season	Station group	Zone 0 (0-8m) Means	Zone 0 Variance	Zone 0 N	Zone 0 t-test	Zone 1 (8-16m) Means	Zone 1 Variance	Zone 1 N	Zone 1 t-test	Zone 2 (16-24m) Means	Zone 2 Variance	Zone 2 N	Zone 2 t-test
1970													
Summer	Inner	317.73	15562	11	0.5394 n.s.	128.67	128.67	3	0.0481 *	199.00	1656.3	2	0.7236 n.s.
	Outer	352.00	15962	10		267.75	7060.3	4		173.75	2587.6	4	
Fall	Inner	58.250	4786.8	20	0.0766 n.s.	11.000	232.80	6	0.0561 n.s.	21.750	519.58	4	0.1231 n.s.
	Outer	116.10	15411	20		30.870	353.27	8		64.375	2218.6	8	
1971													
Spring	Inner	198.10	10213	10	0.9890 n.s.	147.00	4788.0	3	0.1235 n.s.	53.500	312.50	2	0.2510 n.s.
	Outer	198.75	8779.4	8		61.000	1069.0	3		38.750	110.92	4	
Summer	Inner	49.900	2324.3	10	0.5367 n.s.	16.670	30.330	3	0.7247 n.s.	9.0000	128.00	2	0.0329 *
	Outer	66.900	4959.0	10		15.000	28.000	3		38.750	110.92	4	
Fall	Inner	103.33	2839.1	6	0.3501 n.s.	146.50	6384.5	2	0.2504 n.s.	54.500	60.500	2	----
	Outer	178.17	32127	6		52.000	578.00	2		26.000	----	1	
1972													
Spring	Inner	609.29	193010	7	0.1742 n.s.	378.00	----	1	----	423.00	3528.0	2	0.1363 n.s.
	Outer	964.00	55349	4		638.00	147970	2		642.00	12800	2	
Summer	Inner	288.63	97904	8	0.7229 n.s.	128.33	2481.3	3	0.5143 n.s.	19.500	264.50	2	0.6072 n.s.
	Outer	240.11	57485	9		87.000	8264.7	4		54.250	6830.3	4	
Fall	Inner	505.13	53630	8	0.7998 n.s.	342.67	32601	3	0.8540 n.s.	290.50	32005	2	0.1365 n.s.
	Outer	561.90	341410	10		318.00	24552	4		117.75	4676.9	4	
1973													
Spring	Inner	347.88	190040	8	0.6470 n.s.	152.00	6151.0	3	0.0252 *	288.50	45905	2	0.8796 n.s.
	Outer	273.38	12749	8		308.25	2907.6	4		328.67	84044	3	
Summer	Inner	137.00	5525.0	7	0.7018 n.s.	179.00	1399.0	3	0.3140 n.s.	65.500	7080.5	2	0.8663 n.s.
	Outer	120.22	8555.4	9		104.75	11647	4		56.250	2359.6	4	
Fall	Inner	472.00	37306	7	0.8962 n.s.	319.33	7230.3	3	0.2778 n.s.	207.00	18432	2	0.5105 n.s.
	Outer	493.14	139050	7		244.00	6122.0	4		148.75	5444.9	4	
1974													
Spring	Inner	888.00	116890	9	0.8550 n.s.	866.50	115800	3	----	763.50	78013	2	0.8433 n.s.
	Outer	928.90	330840	10		1000.0	----	1		694.00	167100	4	
Summer	Inner	946.27	130406	11	0.2229 n.s.	927.00	560660	3	0.2351 n.s.	319.50	1740.5	2	0.8805 n.s.
	Outer	701.67	255050	9		424.25	22771	4		299.00	28554	4	
Fall	Inner	379.00	26440	12	0.9835 n.s.	297.33	25470	3	0.5299 n.s.	145.50	4900.5	2	0.8893 n.s.
	Outer	381.00	77710	10		216.50	24060	4		134.75	7718.3	4	
1975													
Spring	Inner	1073.1	219920	12	0.9947 n.s.	1260.7	562610	3	0.7856 n.s.	939.50	136760	2	0.7251 n.s.
	Outer	1074.9	628060	10		1131.3	205880	4		750.25	401580	4	
Summer	Inner	69.080	3140.3	12	0.6540 n.s.	79.330	7310.3	3	0.6517 n.s.	48.500	364.50	2	0.0812 n.s.
	Outer	82.330	6020.5	9		54.750	2632.3	4		15.500	238.33	4	
Fall	Inner	612.83	59637	12	0.6939 n.s.	232.33	10444	3	0.1871 n.s.	324.00	3362.0	2	0.0161 *
	Outer	666.00	142010	10		381.50	20267	4		159.50	1883.7	4	
1976													
Spring	Inner	2423.3	147710	12	0.3554 n.s.	1126.4	218650	3	0.3104 n.s.	790.90	118780	2	0.2760 n.s.
	Outer	2005.1	562190	10		1399.8	21985	4		480.00	68544	4	

TABLE 8 continued.

PENNATE DIATOMS cont.

Year & Season	Station group	Zone 0 (0-8m)				Zone 1 (8-16m)				Zone 2 (16-24m)			
		Means	Variance	N	t-test	Means	Variance	N	t-test	Means	Variance	N	t-test
1976 cont.													
Summer	Inner	594.42	457770	12	0.6052 n.s.	49.470	896.16	3	0.3305 n.s.	28.200	0	2	----
	Outer	450.92	345180	10		32.125	142.86	4		8.7000	198.35	4	
Fall	Inner	712.14	213320	12	0.8000 n.s.	456.53	3969.0	3	0.2141 n.s.	531.40	112.50	2	0.8978 n.s.
	Outer	759.55	152410	10		756.10	124060	4		491.33	148130	3	
1977													
Spring	Inner	1972.6	487010	12	0.2585 n.s.	1531.0	133980	3	0.7646 n.s.	1312.3	49078	2	0.0655 n.s.
	Outer	1673.0	208880	10		1464.1	38566	4		603.97	124420	4	
Summer	Inner	896.59	605330	12	0.5991 n.s.	307.03	48906	3	0.5061 n.s.	258.70	13745	2	0.8893 n.s.
	Outer	717.01	545820	9		225.47	4485.2	4		245.62	9240.0	4	
Fall	Inner	1078.2	156110	12	0.3265 n.s.	436.07	25649	3	0.5526 n.s.	302.60	32156	2	0.6838 n.s.
	Outer	1353.8	719690	10		530.57	45953	4		249.97	14911	4	
DESMIDS													
1970													
Summer	Inner	27.545	5851.1	11	0.3485 n.s.	2.3300	10.330	3	0.5415 n.s	2.0000	8.0000	2	0.5057 n.s.
	Outer	4.2000	21.289	10		4.2500	17.583	4		7.0000	.06700	4	
Fall	Inner	1.2000	3.5400	20	0.3472 n.s.	.50000	.30000	6	0.6374 n.s.	.75000	.92000	4	0.8199 n.s.
	Outer	.75000	.93000	20		.75000	1.3600	8		.87500	.69600	8	
1971													
Spring	Inner	.70000	1.7900	10	0.2456 n.s.	.67000	1.3300	3	----	.50000	.50000	2	1.0000 n.s.
	Outer	2.2500	14.500	8		0	0	3		.50000	.33000	4	
Summer	Inner	5.0000	12.000	10	0.7296 n.s.	2.3300	.33000	3	0.0474 *	4.5000	4.5000	2	0.0170 *
	Outer	4.5000	8.2800	10		3.6700	.33000	3		.50000	.33000	4	
Fall	Inner	2.1700	2.1700	6	0.3223 n.s.	4.0000	8.0000	2	0.3118 n.s.	1.5000	.50000	2	----
	Outer	3.1700	3.3700	6		1.0000	2.0000	2		1.0000	----	1	
1972													
Spring	Inner	3.1400	17.140	7	0.4668 n.s.	5.0000	----	1	----	3.5000	4.5000	2	----
	Outer	5.0000	11.330	4		1.0000	2.0000	2		1.0000	0	2	
Summer	Inner	.62500	1.9800	8	----	0	0	3	----	.50000	.50000	2	0.6328 n.s.
	Outer	0	0	9		0	0	4		.25000	.25000	4	
Fall	Inner	2.5000	2.8600	8	0.6607 n.s.	.67000	1.3300	3	----	0	0	2	----
	Outer	2.1000	4.1000	10		0	0	4		0	0	4	
1973													
Spring	Inner	.25000	.50000	8	0.4051 n.s.	0	0	3	----	0	0	2	----
	Outer	.75000	2.2143	8		1.0000	1.3300	4		0	0	3	
Summer	Inner	.86000	2.4800	7	0.5973 n.s.	2.0000	12.000	3	----	.50000	.50000	2	----
	Outer	1.4400	6.2800	9		0	0	4		0	0	4	
Fall	Inner	1.1429	1.1429	7	0.1089 n.s.	1.3300	1.3300	3	0.1468 n.s.	0	0	2	----
	Outer	.28570	.57000	7		.25000	.25000	4		.75000	2.2500	4	
1974													
Spring	Inner	1.0000	3.0000	9	0.5367 n.s.	.67000	2.6700	3	----	2.0000	8.0000	2	----
	Outer	.60000	.93000	10		0	0	1		0	0	4	

TABLE 8 continued.

DESMIDS cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1974 cont.													
Summer	Inner	2.3600	7.8500	11	0.7582 n.s.	2.3300	.33000	3	0.9452 n.s.	5.5000	4.5000	2	0.1270 n.s.
	Outer	2.0000	5.2500	9		2.2500	3.5800	4		2.2500	3.5800	4	
Fall	Inner	.75000	1.6600	12	0.8432 n.s.	.33000	.33000	3	----	0	0	2	----
	Outer	.90000	4.7700	10		0	0	4		.50000	1.0000	4	
1975													
Spring	Inner	.31000	1.1400	12	----	0	0	3	----	0	0	2	----
	Outer	0	0	10		0	0	4		0	0	4	
Summer	Inner	.17000	.15000	12	0.7350 n.s.	0	0	3	----	0	0	2	----
	Outer	.11000	.11000	9		.75000	.92000	4		.25000	.25000	4	
Fall	Inner	.58000	.45000	12	0.5375 n.s.	.33000	.33000	3	0.4631 n.s.	.50000	.50000	2	----
	Outer	.40000	.49000	10		1.2500	3.5800	4		0	0	4	
1976													
Spring	Inner	.55000	1.6500	12	----	1.6700	2.7200	3	----	3.3000	21.780	2	----
	Outer	0	0	10		0	0	4		0	0	4	
Summer	Inner	2.3500	6.6700	12	0.3768 n.s.	0	0	3	----	1.6500	5.4500	2	----
	Outer	1.4100	4.8700	10		.20000	.16000	4		0	0	4	
Fall	Inner	.28000	.91000	12	0.5728 n.s.	0	0	3	----	0	0	2	----
	Outer	.66000	4.3600	10		.43000	.72000	4		0	0	3	
1977													
Spring	Inner	.82500	4.2075	12	0.4979 n.s.	1.1000	3.6300	3	----	0	0	2	----
	Outer	.33000	1.0890	10		0	0	4		.82500	2.7200	4	
Summer	Inner	.56000	1.1800	12	0.9956 n.s.	2.2000	14.520	3	0.3778 n.s.	2.5000	1.2800	2	0.0613 n.s.
	Outer	.56000	1.3800	9		.40000	.21300	4		.42500	.72250	4	
Fall	Inner	1.1080	2.1600	12	0.3574 n.s.	2.2000	3.6300	3	0.9455 n.s.	.85000	1.4500	2	0.6776 n.s.
	Outer	1.9800	7.7400	10		2.0800	6.2200	4		1.6800	5.5600	4	
OTHER ALGAE													
1970													
Summer	Inner	39.090	14708	11	0.3928 n.s.	0	0	3	----	.50000	.50000	2	----
	Outer	5.2000	270.40	10		0	0	4		0	0	4	
Fall	Inner	34.250	8140.4	20	0.3144 n.s.	11.670	66.670	6	0.4676 n.s.	8.2500	2.9200	4	0.6432 n.s.
	Outer	13.600	64.460	20		9.1300	19.840	8		11.750	203.36	8	
1971													
Spring	Inner	25.300	518.23	10	0.3897 n.s.	9.0000	3.0000	3	0.0226 *	12.500	112.50	2	0.5449 n.s.
	Outer	35.250	620.50	8		4.6700	1.3300	3		8.5000	27.670	4	
Summer	Inner	51.100	786.10	10	0.2882 n.s.	30.330	149.33	3	0.4035 n.s.	74.000	7442.0	2	0.1561 n.s.
	Outer	89.900	11784	10		94.330	13960	3		8.5000	27.670	4	
Fall	Inner	11.830	12.970	6	0.2989 n.s.	28.500	264.50	2	0.2976 n.s.	7.5000	.50000	2	----
	Outer	17.500	147.56	6		11.000	50.000	2		8.0000	----	1	

TABLE 8 continued.

OTHER ALGAE cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1972													
Spring	Inner	50.000	2442.7	7	0.1411 n.s.	19.000	----	1	----	26.500	24.500	2	0.1619 n.s.
	Outer	117.50	8476.3	4		56.500	312.50	2		48.500	180.50	2	
Summer	Inner	22.250	1315.9	8	0.1652 n.s.	7.0000	109.00	3	0.6184 n.s.	3.5000	12.500	2	0.5814 n.s.
	Outer	4.5600	16.530	9		11.750	156.25	4		14.250	568.25	4	
Fall	Inner	43.000	472.86	8	0.3065 n.s.	35.670	352.33	3	0.8711 n.s.	8.0000	72.000	2	0.1668 n.s.
	Outer	59.700	1606.9	10		33.000	462.00	4		17.500	32.330	4	
1973													
Spring	Inner	26.380	409.70	8	0.0291 *	22.000	181.00	3	0.3522 n.s.	11.500	60.500	2	0.7947 n.s.
	Outer	7.8800	53.550	8		13.750	64.250	4		14.000	109.00	3	
Summer	Inner	267.43	63183	7	0.1899 n.s.	231.33	1265.3	3	0.0032 **	28.000	800.00	2	0.1583 n.s.
	Outer	134.11	17140	9		51.000	2453.3	4		6.7500	.92000	4	
Fall	Inner	57.290	3485.2	7	0.4467 n.s.	54.670	1066.3	3	0.4377 n.s.	47.500	112.50	2	0.0287 *
	Outer	76.430	659.29	7		40.000	154.00	4		15.250	127.58	4	
1974													
Spring	Inner	5.4400	26.280	9	0.0773 n.s.	18.170	246.17	3	----	44.000	288.00	2	0.0272 *
	Outer	23.500	801.39	10		1.0000	----	1		9.7500	84.250	4	
Summer	Inner	34.460	378.27	11	0.0967 n.s.	41.000	228.00	3	0.6106 n.s.	65.500	112.50	2	0.3521 n.s.
	Outer	76.890	6057.4	9		56.000	2030.0	4		40.250	986.25	4	
Fall	Inner	97.830	9745.1	12	0.5631 n.s.	55.670	1024.3	3	0.2258 n.s.	25.500	144.50	2	0.8925 n.s.
	Outer	75.500	5574.1	10		28.750	402.25	4		27.500	295.00	4	
1975													
Spring	Inner	29.920	1782.4	12	0.2824 n.s.	24.330	1314.3	3	0.8117 n.s.	133.50	34585	2	0.2144 n.s.
	Outer	13.300	563.34	10		35.000	4279.3	4		13.750	202.25	4	
Summer	Inner	13.250	212.57	12	0.1528 n.s.	3.6700	14.330	3	0.2620 n.s.	12.500	4.5000	2	0.0916 n.s.
	Outer	26.110	618.61	9		14.500	200.33	4		5.5000	16.330	4	
Fall	Inner	28.830	219.06	12	0.1223 n.s.	26.330	165.33	3	0.1508 n.s.	34.000	450.00	2	0.4153 n.s.
	Outer	50.600	1937.6	10		57.000	824.67	4		21.500	187.00	4	
1976													
Spring	Inner	116.62	6900.5	12	0.8554 n.s.	45.900	879.88	3	0.1709 n.s.	46.400	2664.5	2	0.4996 n.s.
	Outer	124.37	12900	10		126.42	6668.5	4		25.730	494.22	4	
Summer	Inner	259.01	40222	12	0.2996 n.s.	72.400	2884.9	3	0.1408 n.s.	56.350	49.010	2	0.1356 n.s.
	Outer	174.26	27618	10		24.480	223.92	4		24.450	503.67	4	
Fall	Inner	280.48	22033	12	0.4511 n.s.	142.03	4412.8	3	0.7277 n.s.	131.80	13481	2	0.4494 n.s.
	Outer	230.50	24326	10		159.60	3554.7	4		66.300	3515.0	3	
1977													
Spring	Inner	113.03	7750.3	12	0.8916 n.s.	72.930	1860.3	3	0.4255 n.s.	51.400	0	2	----
	Outer	117.92	5706.7	10		101.55	1870.7	4		82.900	11832	4	
Summer	Inner	127.67	4605.8	12	0.8958 n.s.	48.070	652.90	3	0.1512 n.s.	127.63	4315.2	2	0.1827 n.s.
	Outer	132.37	8983.4	9		112.35	3683.0	4		63.400	1392.9	4	
Fall	Inner	168.71	5611.6	12	0.5389 n.s.	93.970	589.42	3	0.2713 n.s.	137.45	23.805	2	0.0016 **
	Outer	138.74	20989	10		136.37	2970.0	4		45.180	257.08	4	

TABLE 8 continued.

TOTAL ALGAE

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1970													
Summer	Inner	1066.0	508680	11	0.5298 n.s.	693.67	90322	3	0.8806 n.s.	531.50	27145	2	0.1419 n.s.
	Outer	1264.1	494180	10		655.75	104110	4		335.75	11378	4	
Fall	Inner	325.85	32204	20	0.1645 n.s.	213.17	10088	6	0.1829 n.s.	221.30	7835.4	4	0.2400 n.s.
	Outer	424.45	64573	20		307.25	18832	8		295.06	9921.7	8	
1971													
Spring	Inner	887.10	217350	10	0.6495 n.s.	1497.7	2802000	3	0.2605 n.s.	344.00	24642	2	0.1993 n.s.
	Outer	984.75	172280	8		228.70	15516	3		214.50	4423.0	4	
Summer	Inner	374.90	43485	10	0.2467 n.s.	204.00	6697.0	3	0.3871 n.s.	413.50	112810	2	0.2652 n.s.
	Outer	558.00	190340	10		610.33	520100	3		214.50	4423.0	4	
Fall	Inner	356.50	23437	6	0.3442 n.s.	548.00	20808	2	0.2164 n.s.	293.50	9384.5	2	----
	Outer	480.33	69905	6		336.00	7442	2		282.00	----	1	
1972													
Spring	Inner	2131.7	2301400	7	0.0338 *	930.00	----	1	----	897.00	20808	2	0.0245 *
	Outer	4102.5	136630	4		1604.5	386320	2		1556.0	1250.0	2	
Summer	Inner	673.25	405360	8	0.3525 n.s.	238.00	14043	3	0.8049 n.s.	97.500	2244.5	2	0.3506 n.s.
	Outer	434.11	138560	9		297.50	139750	4		214.25	20987	4	
Fall	Inner	2498.8	1121200	8	0.4566 n.s.	1486.0	328920	3	0.8140 n.s.	1166.0	33800	2	0.1547 n.s.
	Outer	3191.2	5637000	10		1406.8	72347	4		713.00	107600	4	
1973													
Spring	Inner	1369.0	513060	8	0.5744 n.s.	1283.7	276930	3	0.3746 n.s.	1484.5	262810	2	0.9019 n.s
	Outer	1581.3	576740	8		1839.5	745170	4		1616.3	1610300	3	
Summer	Inner	2914.8	3962000	7	0.6672 n.s.	3709.3	1406400	3	0.7775 n.s.	549.50	14281	2	0.7497 n.s.
	Outer	2517.6	2650200	9		3137.8	9555300	4		684.00	270580	4	
Fall	Inner	2527.6	412210	7	0.7835 n.s.	2432.3	1032100	3	0.8836 n.s.	1511.5	1709400	2	0.3999 n.s.
	Outer	2662.6	1203400	7		2312.3	1049400	4		974.00	10095	4	
1974													
Spring	Inner	1975.8	501280	9	0.7069 n.s.	2100.7	623200	3	----	2064.5	856740	2	0.4824 n.s.
	Outer	2141.4	1232200	10		2268.0	----	1		1508.8	632000	4	
Summer	Inner	1755.3	470480	11	0.9252 n.s.	1827.0	2093100	3	0.4622 n.s.	781.50	74113	2	0.5338 n.s.
	Outer	1791.3	1009300	9		1224.3	243510	4		1001.0	160520	4	
Fall	Inner	1879.8	832300	12	0.8690 n.s.	1778.3	1749400	3	0.7020 n.s.	1014.5	27613	2	0.7451 n.s.
	Outer	1952.1	1257000	10		1474.0	444550	4		1132.5	194760	4	
1975													
Spring	Inner	3554.1	2388200	12	0.8497 n.s.	4555.3	8786900	3	0.4006 n.s.	4026.5	3561800	2	0.1618 n.s.
	Outer	3372.7	7900400	10		3137.5	953870	4		2244.8	734840	4	
Summer	Inner	960.75	254440	12	0.7721 n.s.	537.33	25966	3	0.0512 n.s.	541.50	2520.5	2	0.7376 n.s.
	Outer	1022.0	181230	9		941.25	54312	4		653.25	171240	4	
Fall	Inner	2124.7	505160	12	0.6648 n.s.	1536.0	225140	3	0.1798 n.s.	2951.0	41472	2	0.0603 n.s.
	Outer	2255.7	458770	10		2570.0	1107100	4		1719.0	386620	4	

TABLE 8 continued.

TOTAL ALGAE cont.

Year & Season	Station group	Zone 0 (0-8m) Means	Variance	N	t-test	Zone 1 (8-16m) Means	Variance	N	t-test	Zone 2 (16-24m) Means	Variance	N	t-test
1976													
Spring	Inner	6335.2	5059700	12	0.3236 n.s.	3167.9	590470	3	0.0148 *	2546.0	1145800	2	0.2571 n.s.
	Outer	5377.4	4672500	10		5403.2	680080	4		1709.4	331220	4	
Summer	Inner	2834.4	3169100	12	0.6497 n.s.	1583.4	65664	3	0.6916 n.s.	1475.6	88.445	2	0.1436 n.s.
	Outer	2484.8	3095000	10		2169.6	5508400	4		1051.4	97029	4	
Fall	Inner	2828.4	1525800	12	0.9857 n.s.	2273.7	1316300	3	0.6493 n.s.	2857.6	480100	2	0.1763 n.s.
	Outer	2838.9	2217300	10		2601.9	440200	4		2100.8	92143	3	
1977													
Spring	Inner	5135.8	2296300	12	0.2109 n.s.	4138.5	1474900	3	0.5937 n.s.	3538.3	266160	2	0.0630 n.s.
	Outer	4347.8	1699300	10		4538.9	429760	4		2111.5	465710	4	
Summer	Inner	3465.6	2143100	12	0.7038 n.s.	1408.3	550420	3	0.0953 n.s.	3740.5	256540	2	0.0072 **
	Outer	3192.0	3191100	9		2815.0	975010	4		2019.9	120330	4	
Fall	Inner	4913.9	10086000	12	0.7835 n.s.	2858.0	1572600	3	0.2143 n.s.	3909.7	4076100	2	0.9617 n.s.
	Outer	4579.6	5152300	10		4230.1	1611800	4		3993.4	3415000	4	

Zone 0		Zone 1		Zone 2	
Inner greater	1 + 0	Inner greater	0 + 2	Inner greater	6 + 11
Outer greater	1 + 0	Outer greater	7 + 4	Outer greater	4 + 0

In Zone 0 the cases of significant difference in abundances at inner and outer stations have been equally divided in preoperational and operational years. No evidence of plant operation effects shows in these data.

With the plant's thermal plume in Zone 1 most of the time, the significantly greater abundances in this zone have been at the outer stations in 11 of 13 cases. In the preoperational years all seven cases were of greater abundances at the outer stations; greater abundances at the outer stations appear to be a natural feature of this depth zone. In operational years four of six cases were of greater abundances at the outer stations, which does not gainsay greater abundances at these stations as a natural feature of the zone.

In Zone 2 during the preoperational years six of the ten cases of significant differences involved higher abundances in the inner stations; in the operational years all 11 cases have been of higher abundances in the inner stations. With the plant's thermal plume in Zone 1 most of the time, and with Zone 2 beginning at about two kilometers off shore and continuing farther, it is unlikely that waste heat from the plant has caused the higher abundances in the inner stations of this zone.

With the local currents moving alongshore, an hypothesis that plant operation inhibits phytoplankton abundances in Zone 1 inner while stimulating them in Zone 2 inner does not appear tenable. The abundance curves of Figure 8 do not support it. No convincing evidence of plant operation affecting local phytoplankton numbers has surfaced from these analyses.

CONCLUSIONS

During the thermal bar condition of 14 April 1977 surface water temperatures ranged from less than 2^{o}C offshore to more than 10^{o} at the beach and phytoplankton were more than twice as abundant near shore than offshore. Average concentrations of the conservative ions, sulphate and chloride, were not significantly higher inshore of the bar than offshore. It is concluded that spring warming of the water, not impoundment of shore runoff, triggered the higher abundances of phytoplankton on the shoreward side of the thermal bar.

In the dominant and codominant taxa of the Cook Plant phytoplankton collections, green algae and diatoms have continued to occur with preoperational frequencies. Since 1972 flagellates appear to be slightly less frequent as dominants than before, and blue-green algae appear to have increased in their frequency of dominance since 1973. Increased dominance of blue-greens in summer and fall in recent years has been found in other studies and is an accepted fact; the degree of dominance of these algae in the Cook Plant collections, however, is in part an artifact due to the counting of individual cells in most of the forms which was begun with the collections of 1974. The trends in dominants are consistent with known changes in the lake; there is no evidence that operation of Cook Plant has produced the changes.

The centric diatom *Cyclotella comensis*, previously collected in others of the Great Lakes and from other parts of Lake Michigan, appeared for the first time in the Cook Plant collections in October 1975 and has been taken with increasing regularity in the seasonal surveys since then. It occurred for the first times in 100% of the station samples in October 1976 and in July and October 1977. It attained dominant or codominant status in five cases in October 1976 and 15 cases in July 1977. Its failure to achieve dominance in

October 1977 is consistent with an autumn silica depletion in the epilimnion. The record on this diatom indicates some change in the lake, not any effect of Cook Plant operation.

The percentage compositions of the phytoplankton by five major algal groups (blue-greens, greens, flagellates, diatoms, and desmids-and-others) at four inshore stations in front of the plant and at two inshore reference stations distant from the plant have been compared from July 1970 through November 1977. In both preoperational and operational years the five community components have shown many similarities of temporal change in the two station groups; in the operational years the similarities have, if anything, been greater than during preoperation. Due to a change in counting technique in 1974, blue-green algae showed an increase in that year which has continued since. No dissimilarities in community composition attributable to plant operation have been revealed by this method of analysis.

The numbers of phytoplanktonic forms collected during the seasonal major surveys have shown generally increasing trends since 1971 in both inner stations near the plant and outer reference stations in all three depth zones. The trends toward increasing numbers of forms are attributable to the lake's eutrophication process, not to Cook Plant operation.

Of the nine major algal categories (separately, not combined to five as was done for percentage composition of the community) and total algae, only filamentous blue-greens have shown increases limited to the operational years. In Zone 0 the increases at the outer stations have equalled or exceeded those at the inner stations; in Zone 1 the summer increases have been greater at the outer stations; in Zone 2 summer increases have been greater at the inner stations in 1976 and 1977. Zone 2 being offshore, the summer increases there are attributed to summer silica depletion in the epilimnion of the offshore

waters, rather than to plant operation.

Coccoid blue-greens showed notable fall increase in preoperational 1974 (due at least in part to the counting change then) and this pattern has continued since in both inner and outer station groups. There is no clear evidence of any plant operation effect.

The changes in mean abundances of the other catagories have been:

Flagellates	Increasing trend since 1970
Pennate diatoms	" " " "
Centric diatoms	" " " "
Total algae	" " " "
Desmids	Essentially no change
Filamentous greens	" " "
Other algae	" " "
Coccoid greens	" " "

The trends toward increasing abundances show in both station sets and all three depth zones and are attributable to the lake's eutrophication, rather than to effects of Cook Plant operation.

T-tests of significance of difference between seasonal mean densities of nine algal categories and total algae at inner and outer stations in each of the three depth zones during the years 1970 through 1977 have been performed. Of 591 paired comparisons, significant differences between mean densities at inner and outer stations were found in only 36 cases; these amount to 6% of the comparisons.

Summarizing by categories, with the numbers of significant differences in operational years underlined, gives: filamentous greens 0 + 0; coccoid blue-greens 0 + 1; desmids 2 + 0; filamentous blue-greens 0 + 4; coccoid greens 2 + 2; centric diatoms 2 + 2; pennate diatoms 3 + 1; total algae 2 + 2; other algae 5 + 1; and flagellates 4 + 3. Only in the filamentous blue-greens were all the significant differences in the operational years; however, three of the four cases were in offshore Zone 2. There is no

convincing evidence of plant operation selectively affecting any of the algal categories.

Summarizing by years (with operational years underlined) gives: 1970 (2), 1971 (6), 1972 (5), 1973 (5), 1974 (2), <u>1975</u> (<u>6</u>), <u>1976</u> (<u>4</u>), <u>1977</u> (<u>6</u>). The numbers of significant differences in operational years are within the range of natural variation established during the preoperational years. There is no evidence that plant operation has produced more significant differences.

Summarized by depth zones, with the station group having the greatest density of algae indicated and with operational years underlined, the cases of significant differences become:

Zone 0	Zone 1	Zone 2
Inner greater 1 + <u>0</u>	Inner greater 0 + <u>2</u>	Inner greater 6 + <u>11</u>
Outer greater 1 + <u>0</u>	Outer greater 7 + <u>4</u>	Outer greater 4 + <u>0</u>

Cases of significant differences were equally divided in Zone 0; in Zone 1 where the plant plume is located most of the time 11 of the 13 cases were of greater abundances in the outer stations; in offshore Zone 2, 17 of the 21 cases involved higher abundances at the inner stations. In this situation where the local currents move parallel to shore, an hypothesis that plant operation inhibits phytoplankton abundances in Zone 1 inner while stimulating them in Zone 2 inner is not supported by the abundance curves of Figure 8 and does not seem tenable.

No convincing evidence of plant operation affecting local phytoplankton numbers has surfaced from these analyses.

The Wilhm and Dorris diversity indices of Cook Plant phytoplankton collections taken during the seasonal surveys of 1970 through 1977 have shown an increasing trend since 1972. The increases have taken place in both inner

and outer station groups and in all three depth zones. The increasing diversities are attributed to the eutrophication of the lake; there is no evidence from this study that plant operation has adversely affected (lowered the diversity of) the phytoplankton community, instead the community has in the operational years continued to be more diverse than it was in the preoperational years.

Values of phytoplankton redundancy for collections during the seasonal surveys of 1970 through 1977 have been calculated. Plots of mean redundancies against time show visual evidence of a trend, beginning in 1973, for redundancies to become somewhat lower. If real, the trend would indicate a tendency for the species in the community to become more equal in numbers of individuals. Rising redundancies (one or a few species dominating the community) would be an adverse effect.

Parallelism between the curves for redundancies at inner and outer station groups has, since 1972, been much better than in 1970 and 1971. This indication that changes in redundancy in the two station groups are now more alike than in the earliest years is taken to mean some change in the lake, not any effect of Cook Plant operation.

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